

FSS in support of MBSE

Final Presentation – Demonstration

TEC-ED & TEC-SW Final Presentation Days 2014

P. M. Fischer

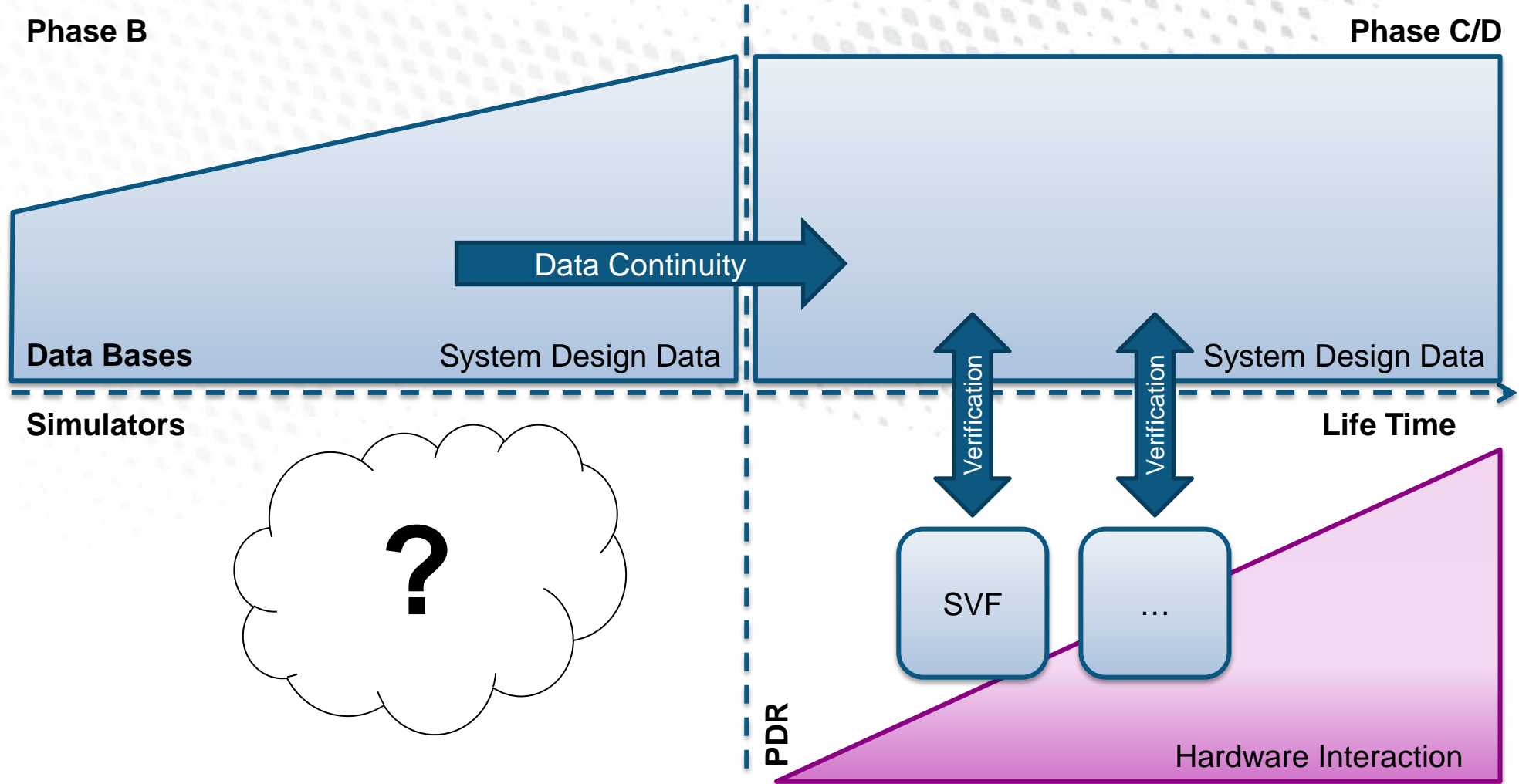
9th December 2014



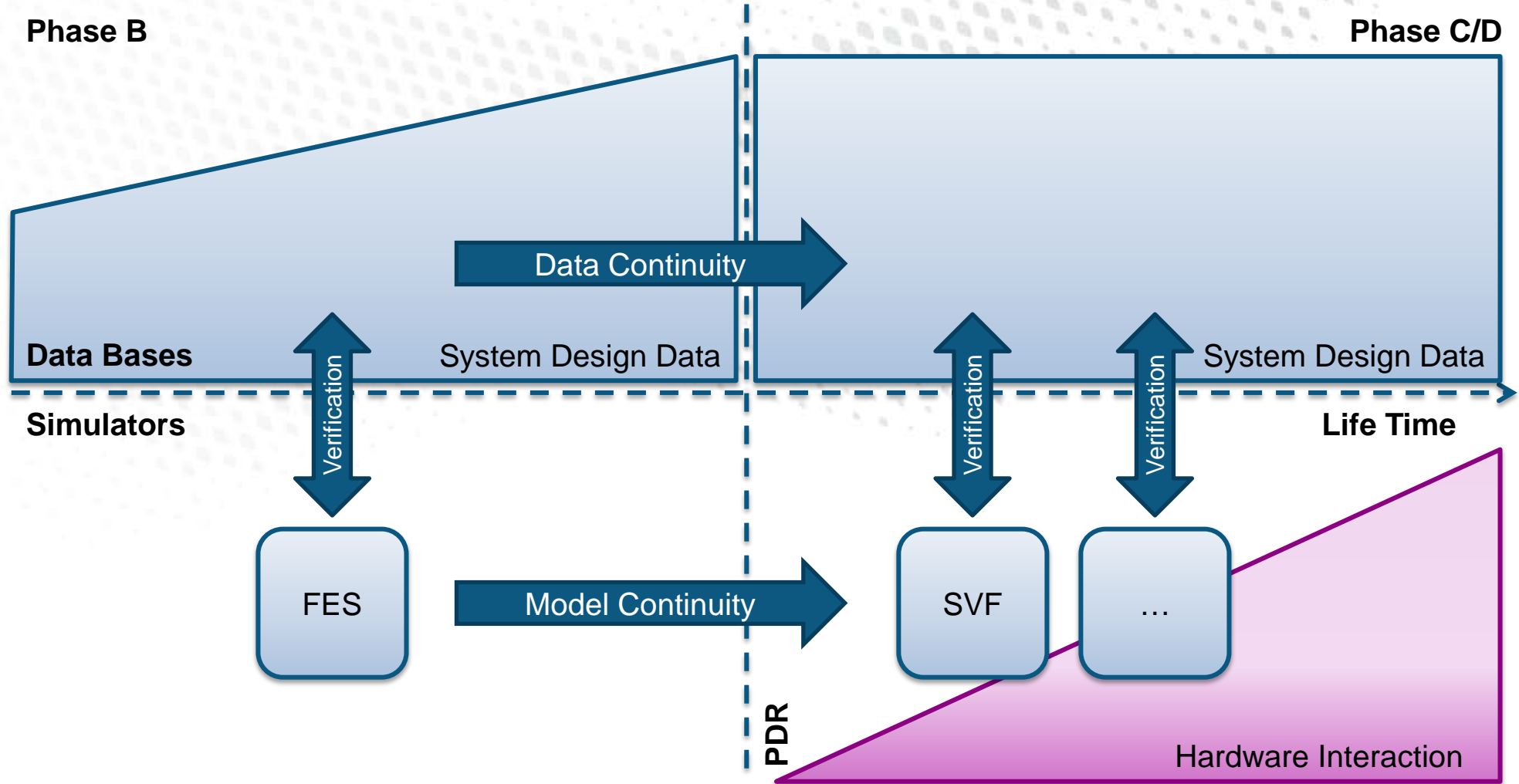
AIRBUS
DEFENCE & SPACE

FSS in MBSE Study Goal and Consortium

Need to Improve Design Maturity already in Phase B

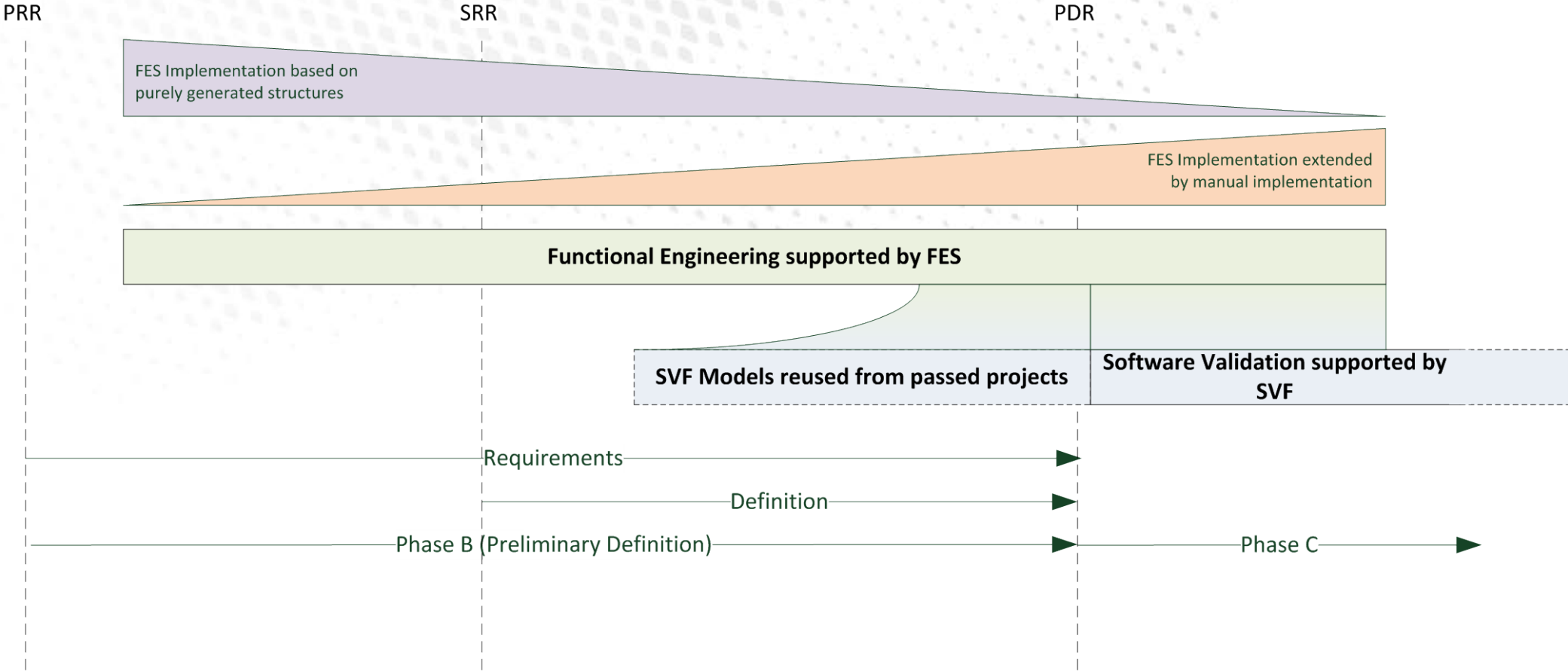


Goal I: Configure Simulator from System Design to Verify Before PDR



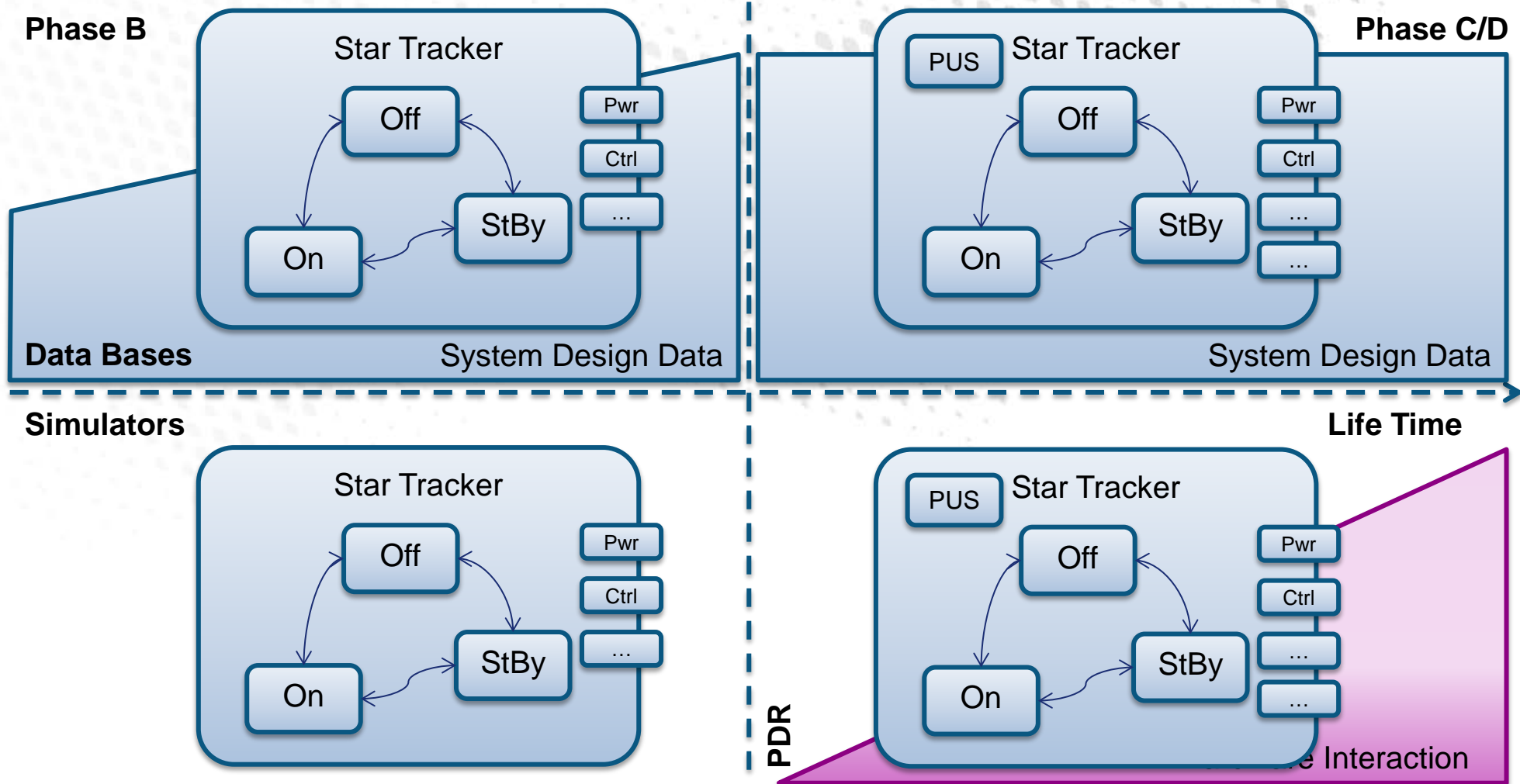
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Goal II: Model Continuity from FES to SVF in the Design Phases



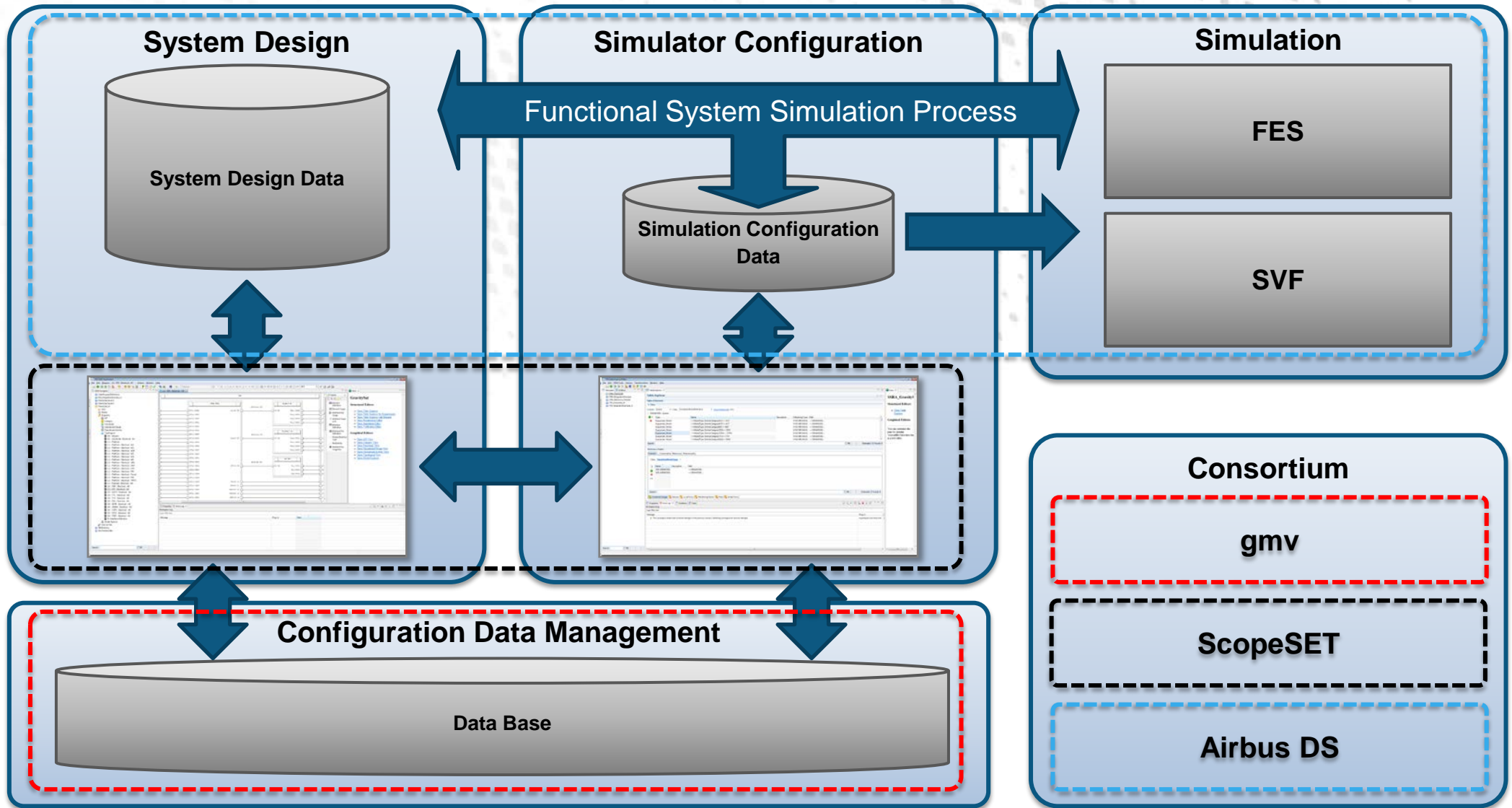
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Example: Common Components in System and Simulation Data



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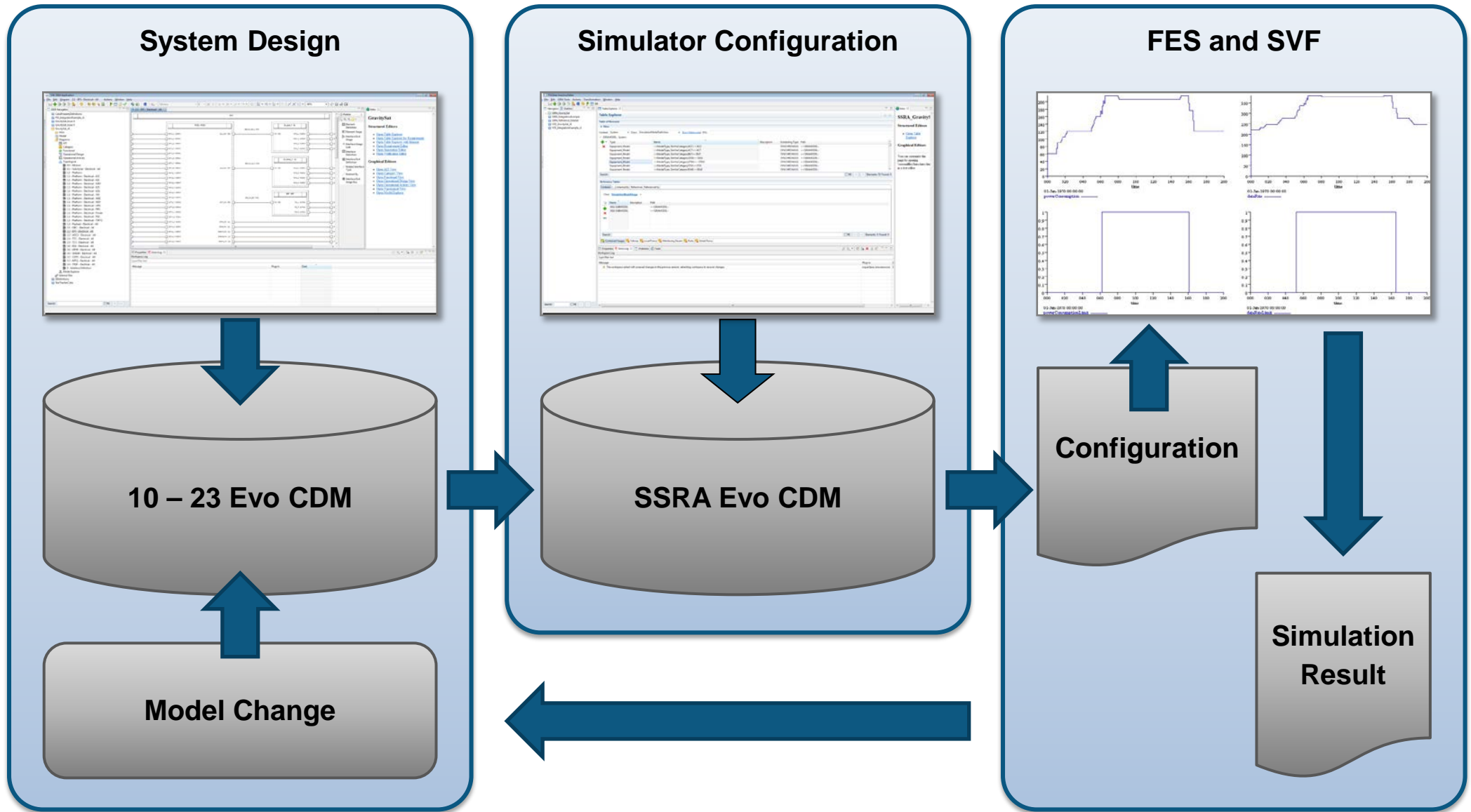
Data, Tools, Processes to uses System Data for Simulator Configuration



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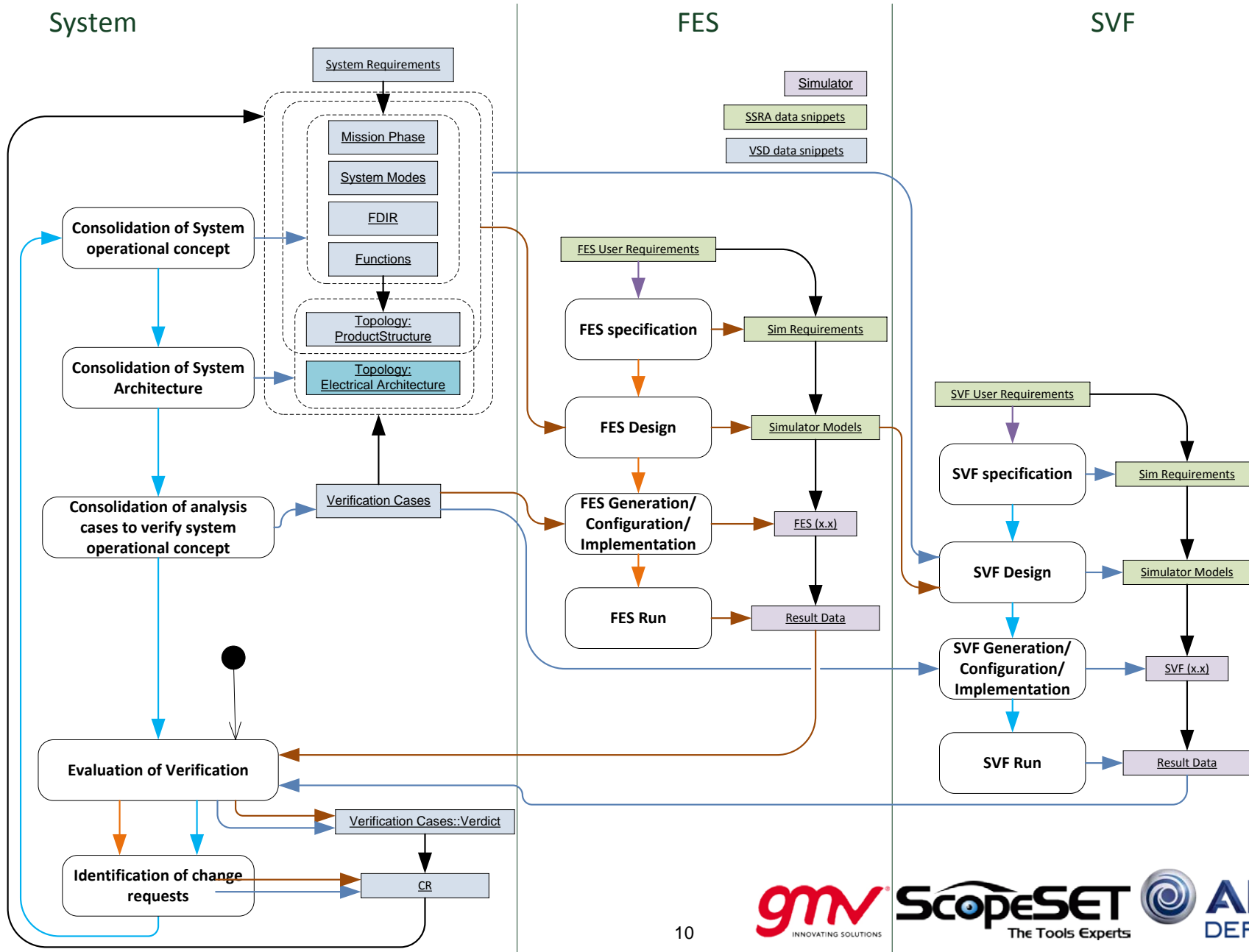
Functional System Simulation Process and Concepts

Overall Process of the Functional System Simulation

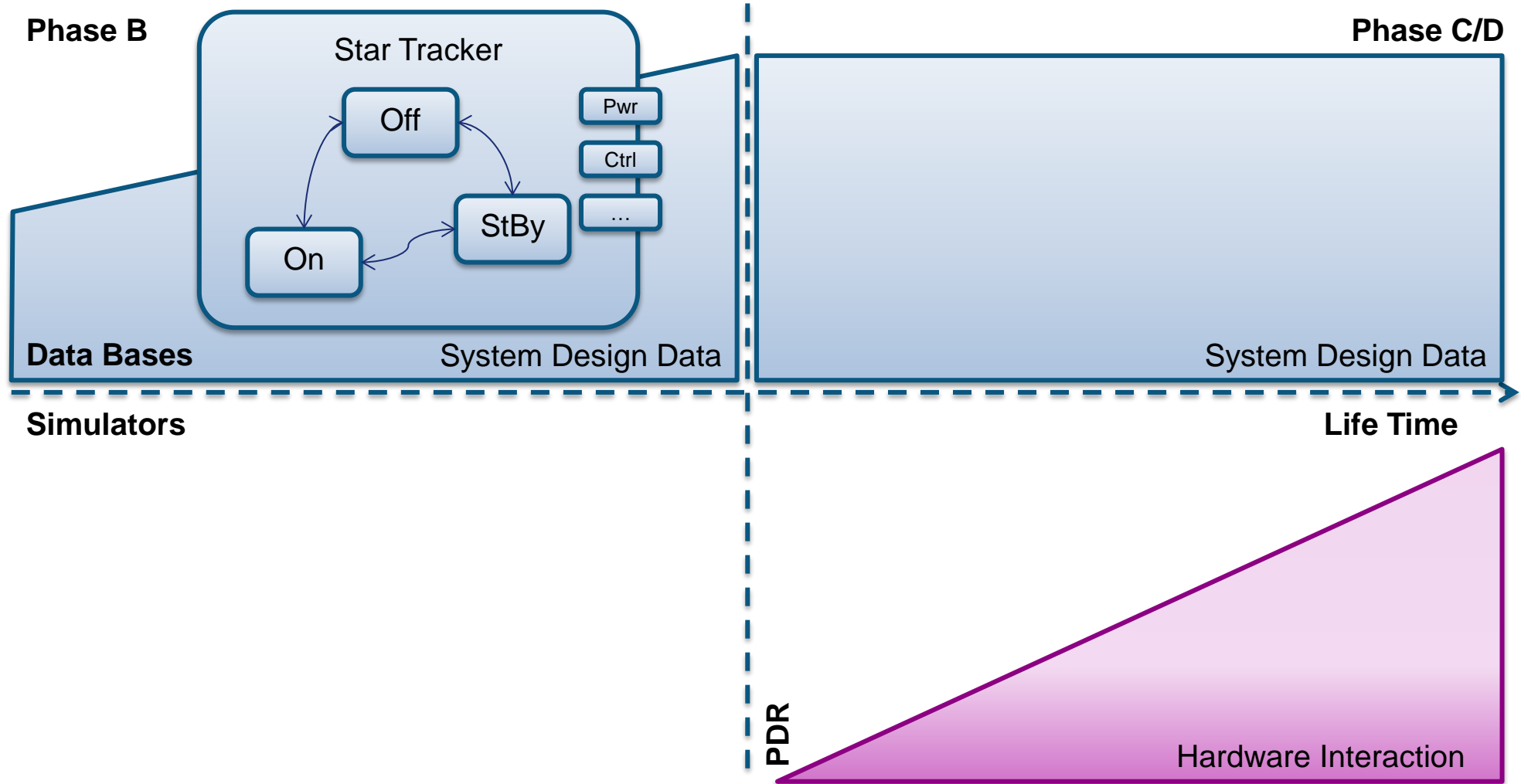


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Functional System Simulation Process in Detail



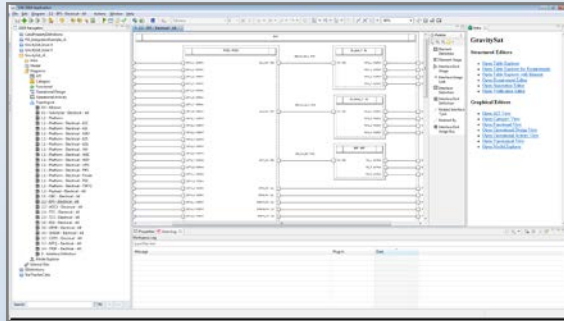
Example: Modelling the Star Tracker in the System Design Data



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Modelling System Design Data in 10-23 Evo using VSD

System Design



10 – 23 Evo CDM

System Design Data is stored in an Evolution of 10 - 23

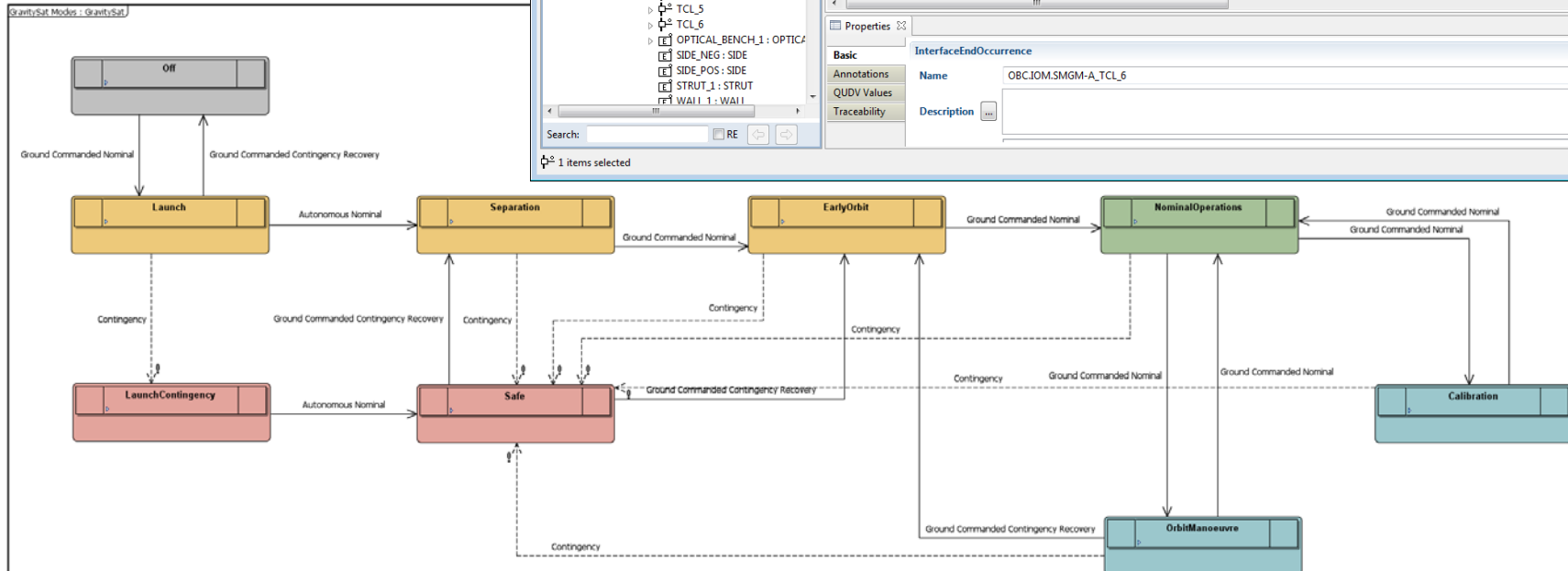
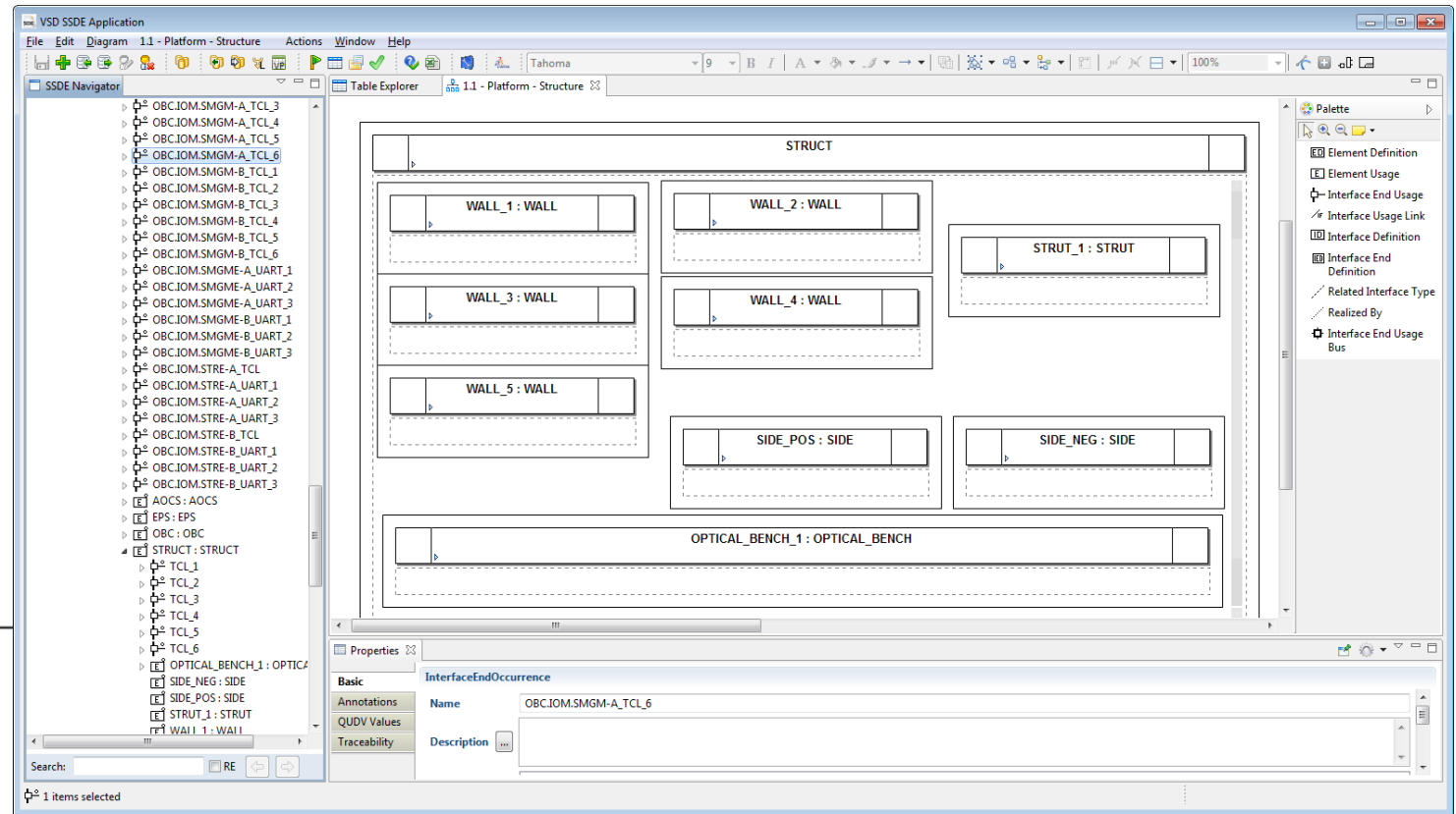
- Authoring of Data covered by VSD SSDE

System Design Data content of a Sample Mission including

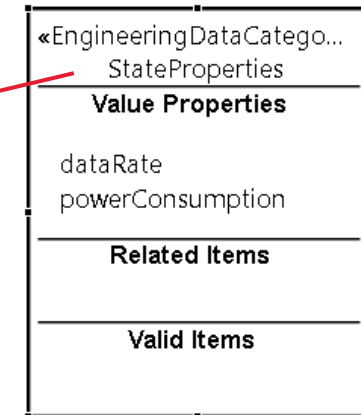
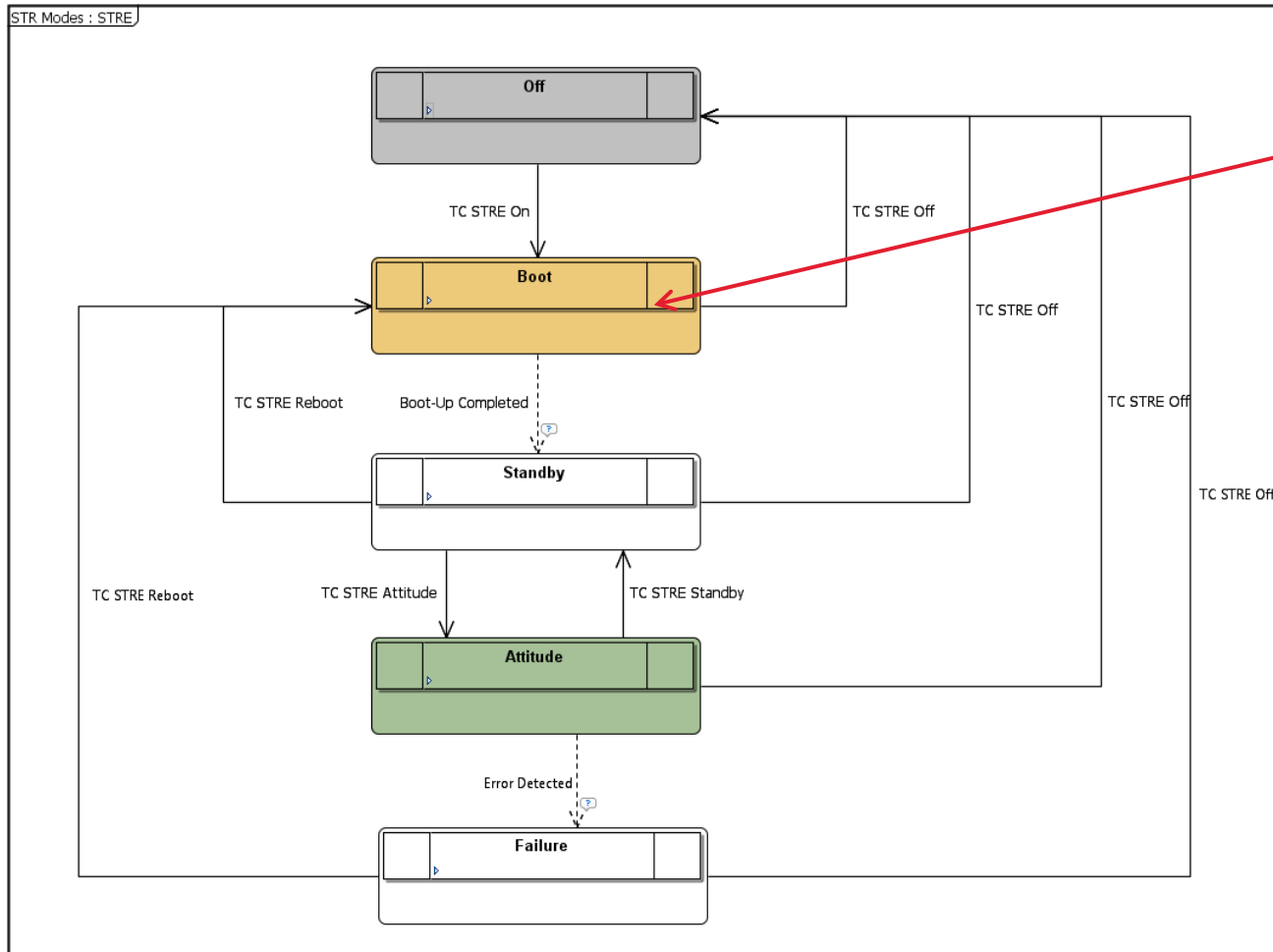
- Mission Specification
- System Specification
 - Related to later demonstration cases suchg as FDIR and Data Rates
- System Operational Concept
- System Modes including PUS Services
- System Architecture Definition
- System Verification with Analysis Cases

Modelling in VSD – Such as System Operational Concept

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Example of the Equipment modes Extended by Categories



| | | | |
|-----|----------|--------------------|----------------|
| + | Attitude | StateProperties | >>ElementOccur |
| + | Boot | StateProperties | >>ElementOccur |
| - | Failure | StateProperties | >>ElementOccur |
| ... | Off | Simulation, StateF | >>ElementOccur |
| o | Standby | StateProperties | >>ElementOccur |

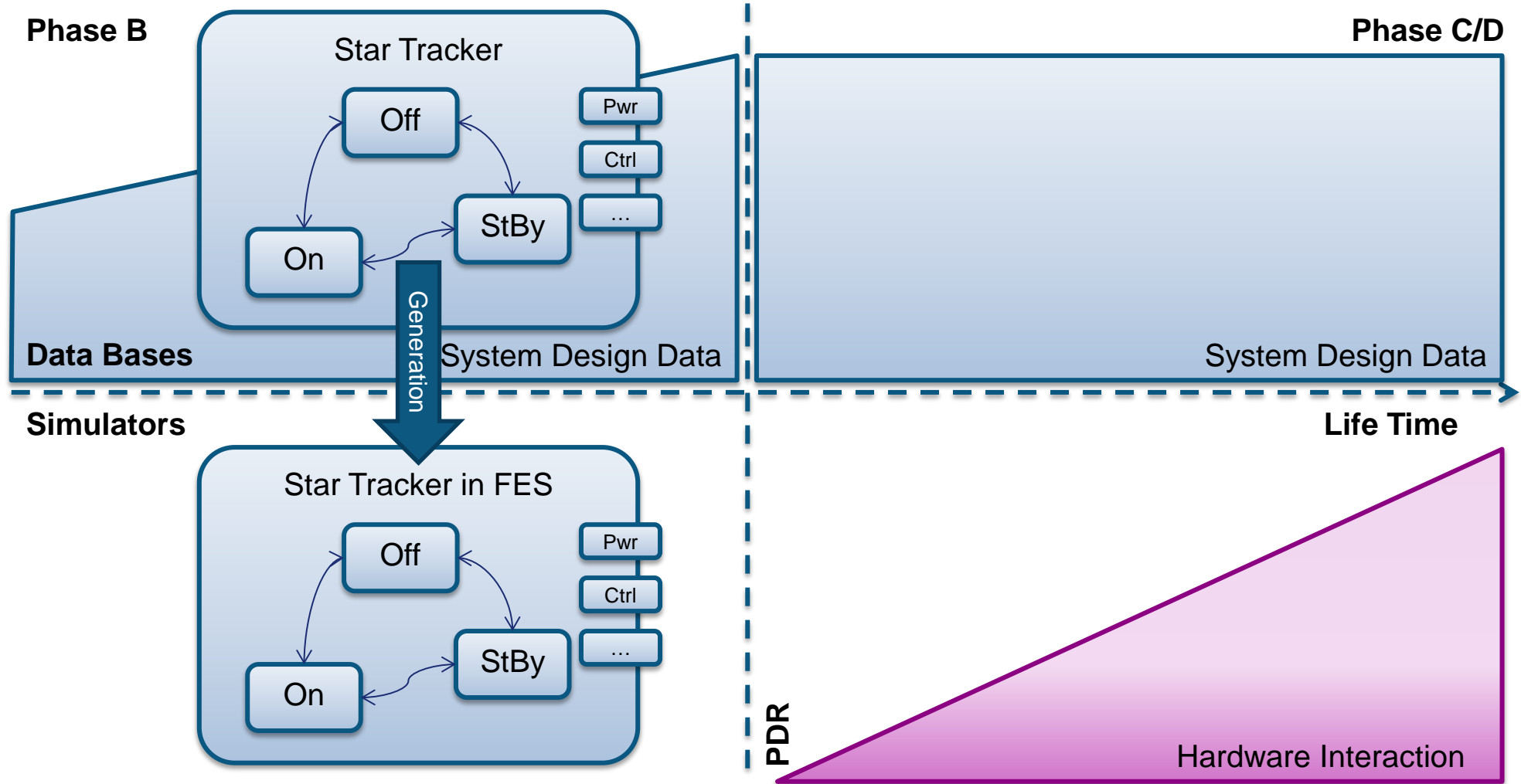
Search:

Check Annotations
 Data Groups
 Dsi
 Merge Annotation
 Relat

| Basic | + | Category/Property | Pr... | Unit |
|-------------|-----|---------------------|-------|----------------------|
| Annotations | - | StateProperties | | |
| QUDV Values | ... | =X dataRate | 10 | kilo bits per second |
| | | =X powerConsumption | 10 | watt |

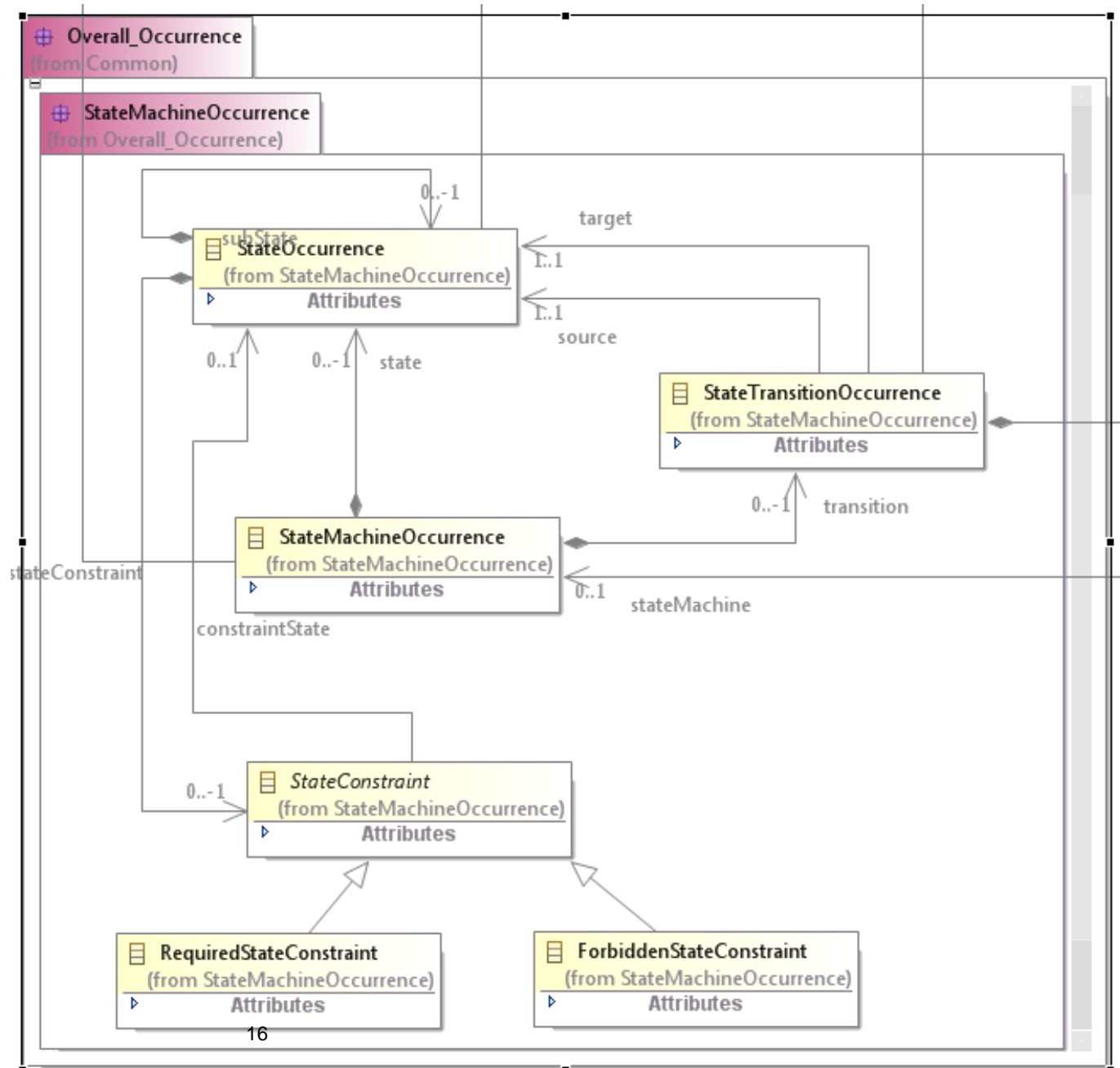
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Example: Transferring the System Design into the FES Configuration



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Managing Simulator Configuration Data in SSRA Evolution



Populating the SSRA Model from the System Model

System Design Data authored in SSDE

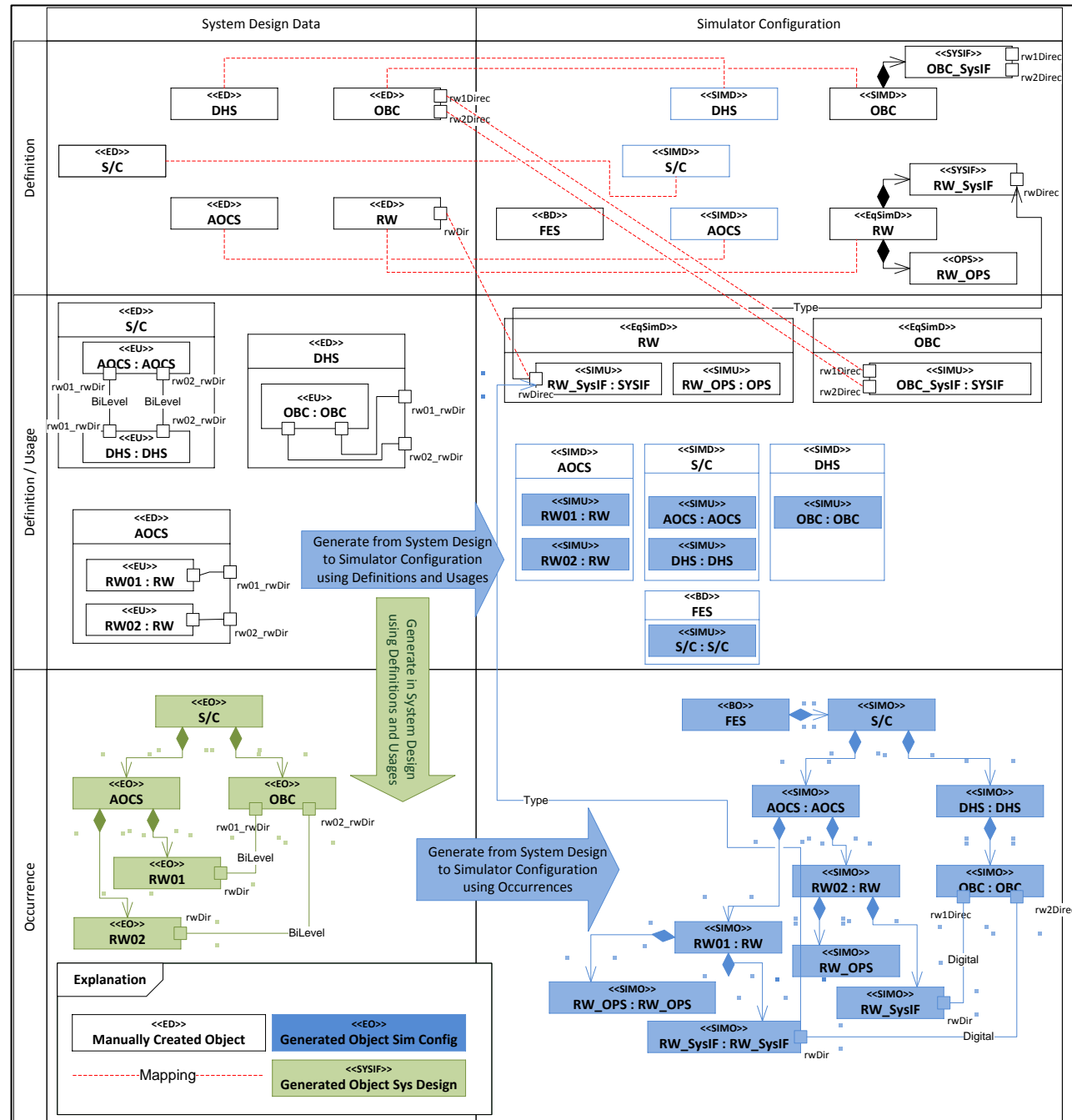
- Using Occurrence Generator in SSDDE

Simulator Configuration gets Generated

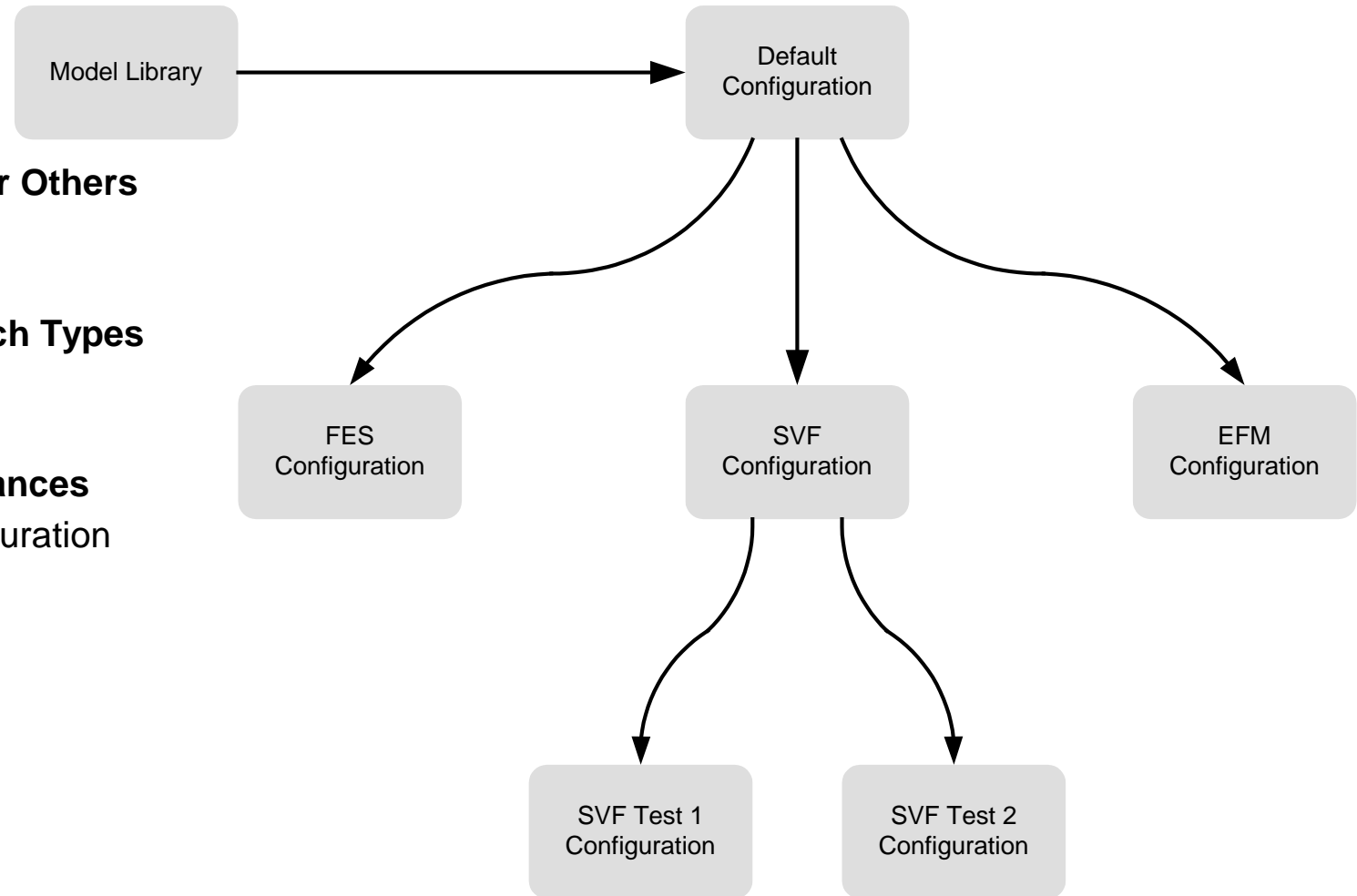
- Simulation Models imported from Library
- Manual Modifications Possible

Simulator Configuration Population

- Derived from System Model
- Generates all Missing Data such as:
 - Complete Product Structure
 - State Machines
 - Services



SSRA Configuration and DataSet Management



Default Configuration as Root for Others

- Contains Common Information

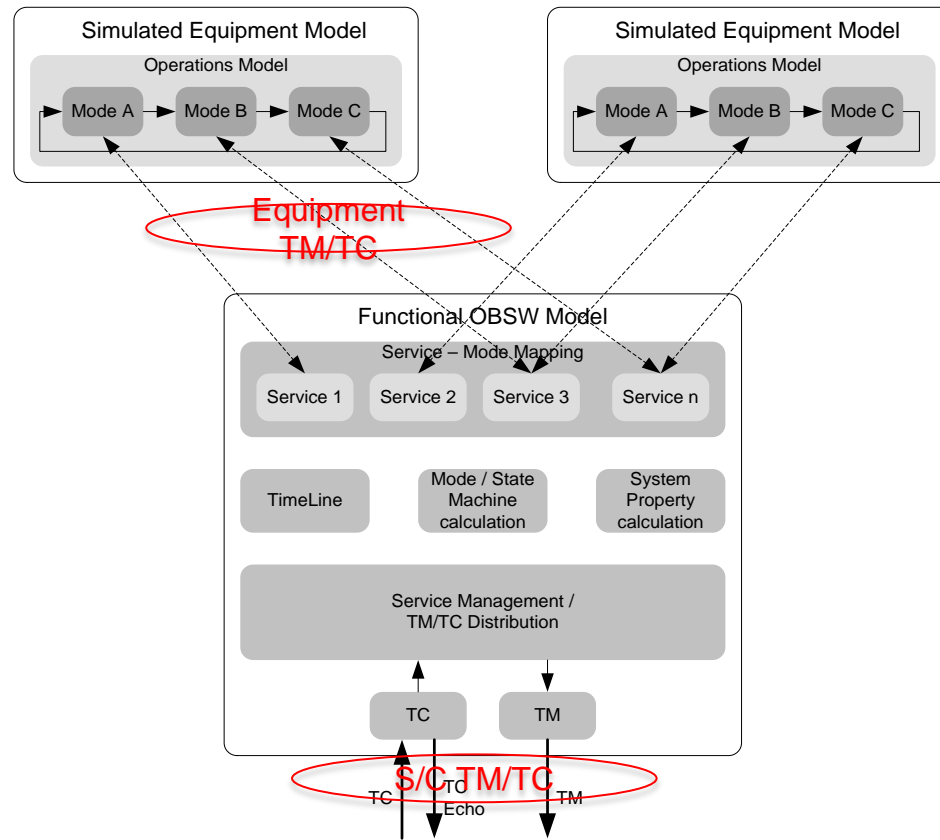
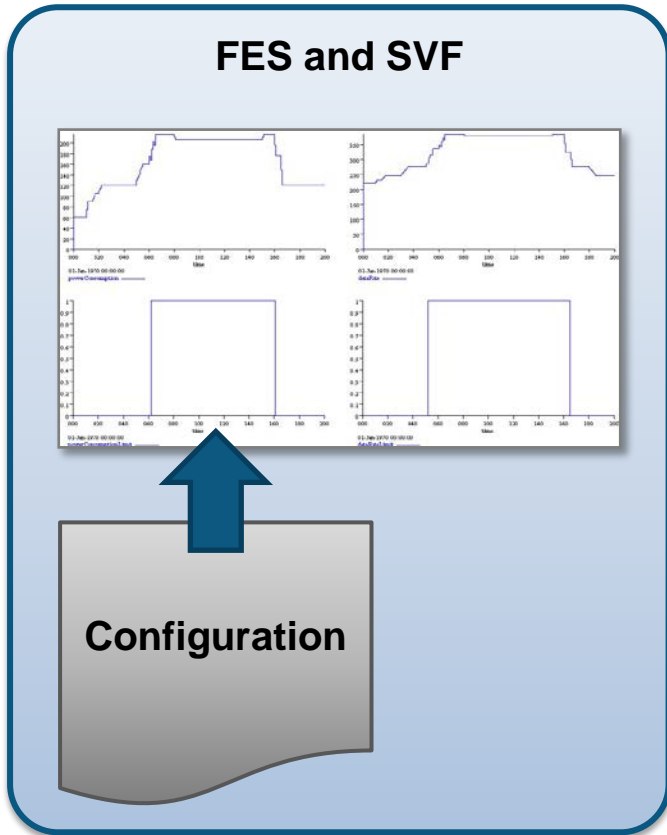
Individual Modifications for Bench Types

- Such as Interfaces for SVF

Individual Config for Bench Instances

- Contains Bench Specific Configuration

FES Architecture Communcation and its Configuration



Communication based on equipment mode function calls

- Service to Mode Mapping

Functional OBSW Model triggers equipment modes

- Trigger of mode related functions

Configured by Excel Based Input

Mapping SSRA to FES Configuration

FES Configured by Excel File including

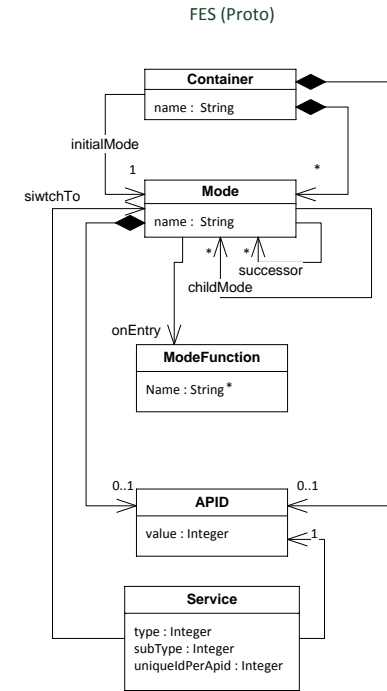
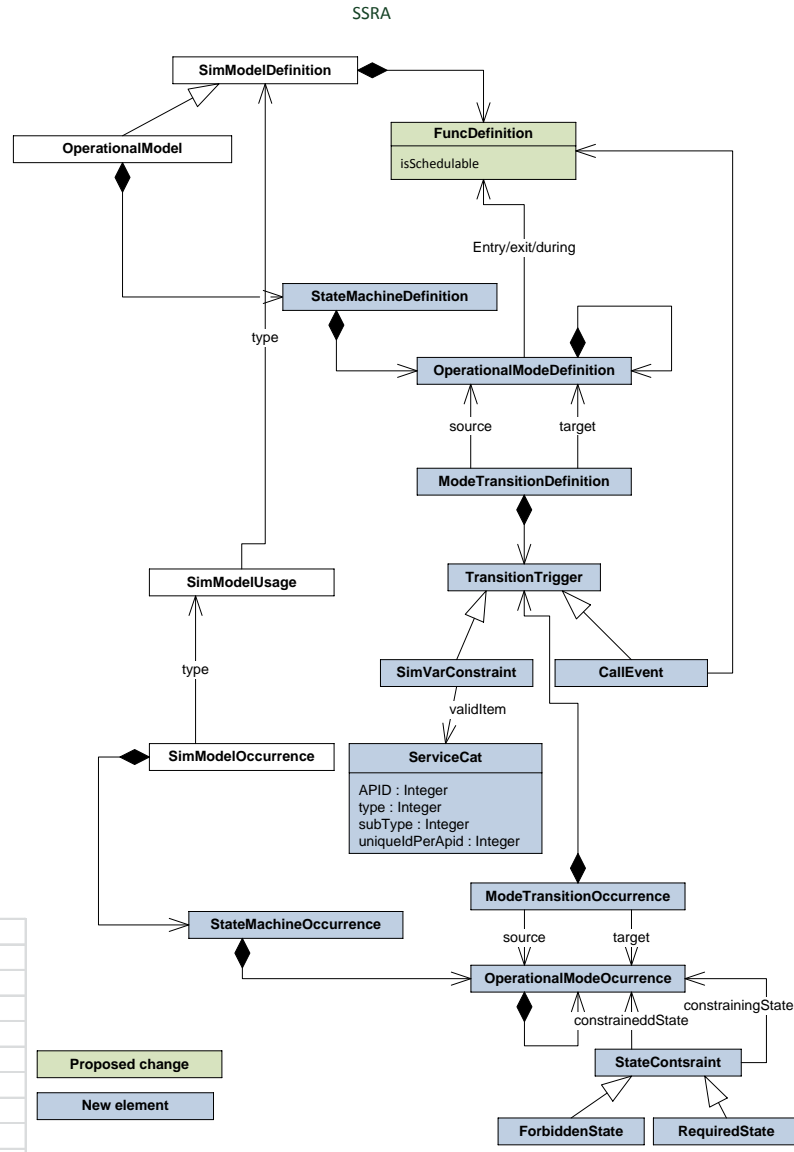
- Model Instantiation
- Scheduling
- State Machines
- Transitions
- Services

Need to Create Configuration from SSRA

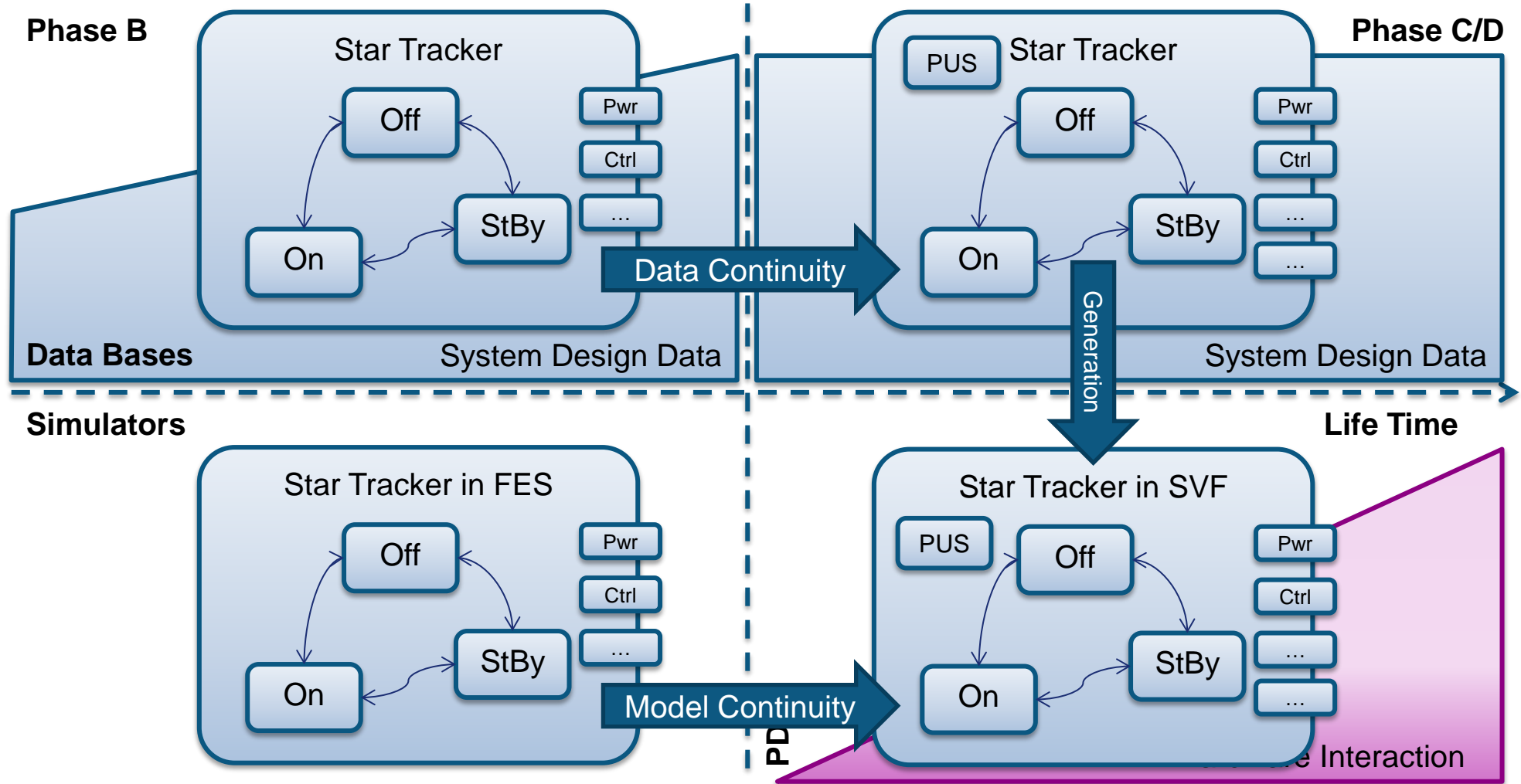
| | | | |
|--------------|--------|----------|--|
| registerMode | GPSR_A | Off | |
| registerMode | GPSR_A | Startup | |
| registerMode | GPSR_A | Standby | |
| registerMode | GPSR_A | Navigate | |
| registerMode | GPSR_A | Failure | |

| | | | |
|-------------------|--------|----------|----------|
| registerSuccessor | GPSR_A | Off | Startup |
| registerSuccessor | GPSR_A | Startup | Standby |
| registerSuccessor | GPSR_A | Startup | Off |
| registerSuccessor | GPSR_A | Standby | Startup |
| registerSuccessor | GPSR_A | Standby | Navigate |
| registerSuccessor | GPSR_A | Standby | Off |
| registerSuccessor | GPSR_A | Navigate | Standby |
| registerSuccessor | GPSR_A | Navigate | Off |
| registerSuccessor | GPSR_A | Navigate | Failure |

| #registerChildMode | param1 | param2 | param3 | param4 | param5 |
|--------------------|--------|--------|--------|----------|--------|
| registerChildMode | AOCS | STB | MGM_C | Off | |
| registerChildMode | AOCS | STB | CESS_1 | Off | |
| registerChildMode | AOCS | STB | CGPS_A | Off | |
| registerChildMode | AOCS | STB | CGPS_B | Off | |
| registerChildMode | AOCS | STB | GPSR_B | Off | |
| registerChildMode | AOCS | STB | CESS_4 | Off | |
| registerChildMode | AOCS | STB | GPSR_A | Off | |
| registerChildMode | AOCS | OCM | GPSR_A | Navigate | |
| registerChildMode | AOCS | OCM | MTQ_1 | On | |
| registerChildMode | AOCS | OCM | STRE_B | Attitude | |
| registerChildMode | AOCS | OCM | STRE_A | Attitude | |
| registerChildMode | AOCS | OCM | MTQ_2 | On | |
| registerChildMode | AOCS | OCM | CESS_6 | On | |
| registerChildMode | AOCS | OCM | MGM_A | On | |
| registerChildMode | AOCS | OCM | GPSR_B | Navigate | |

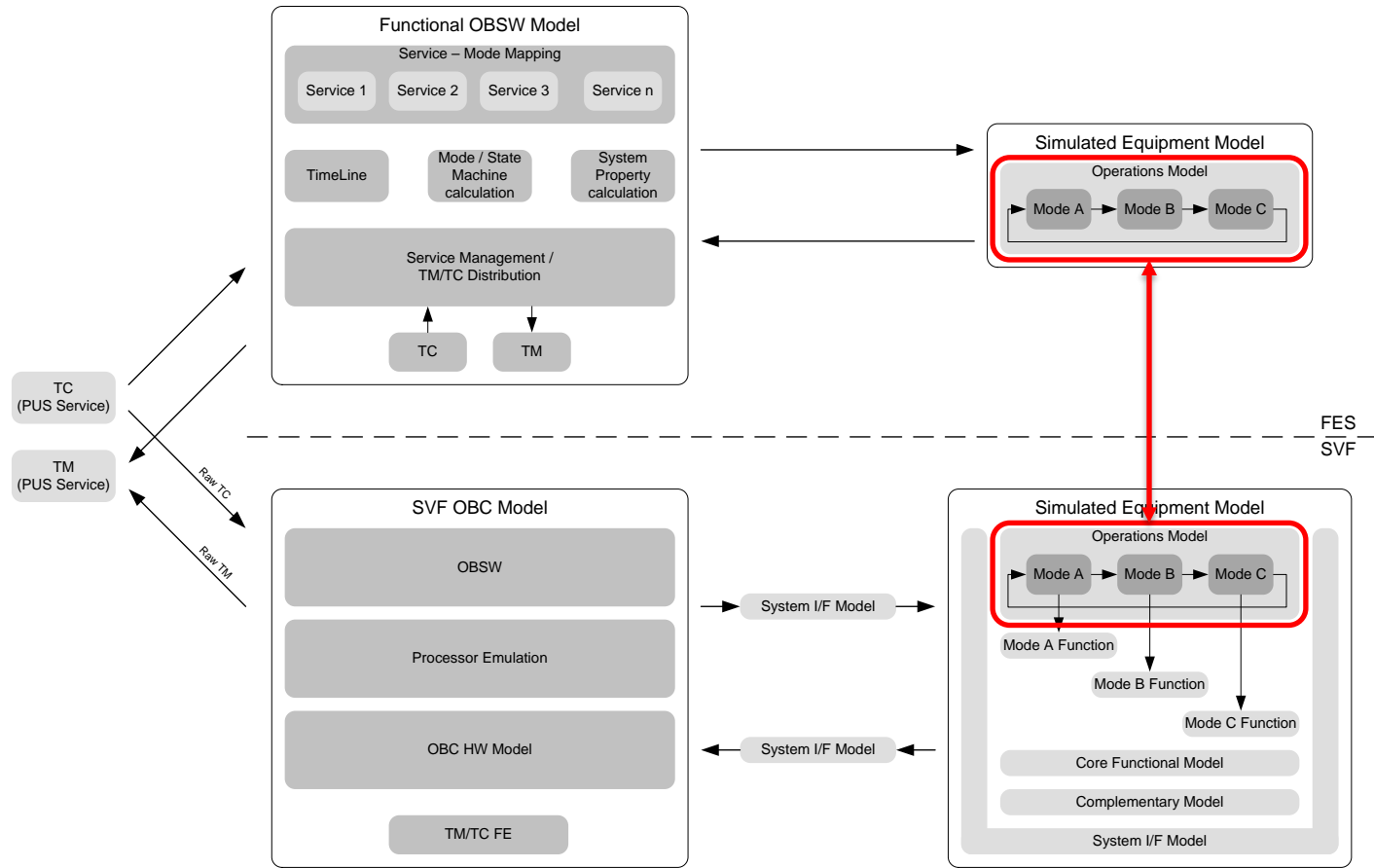
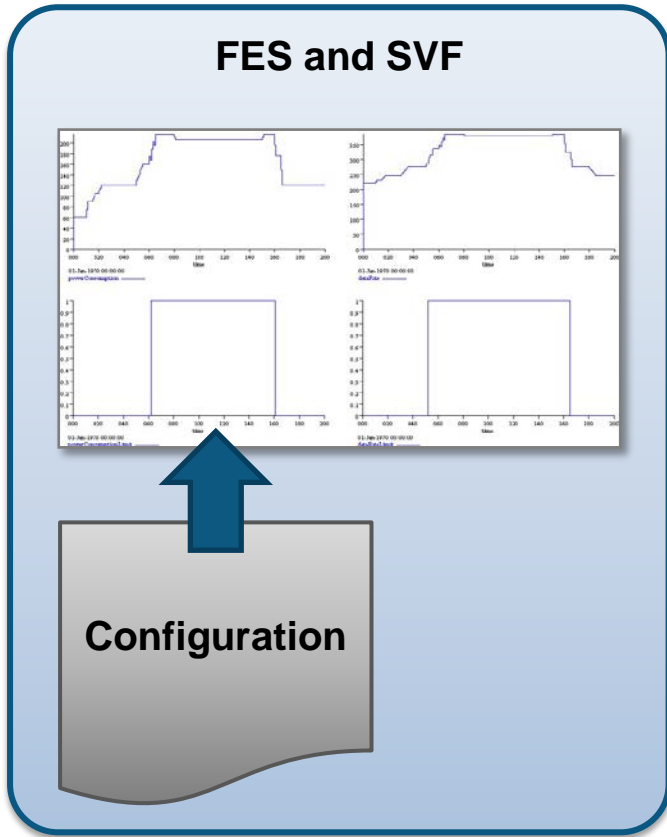


Example Common Components in System and Simulation Data



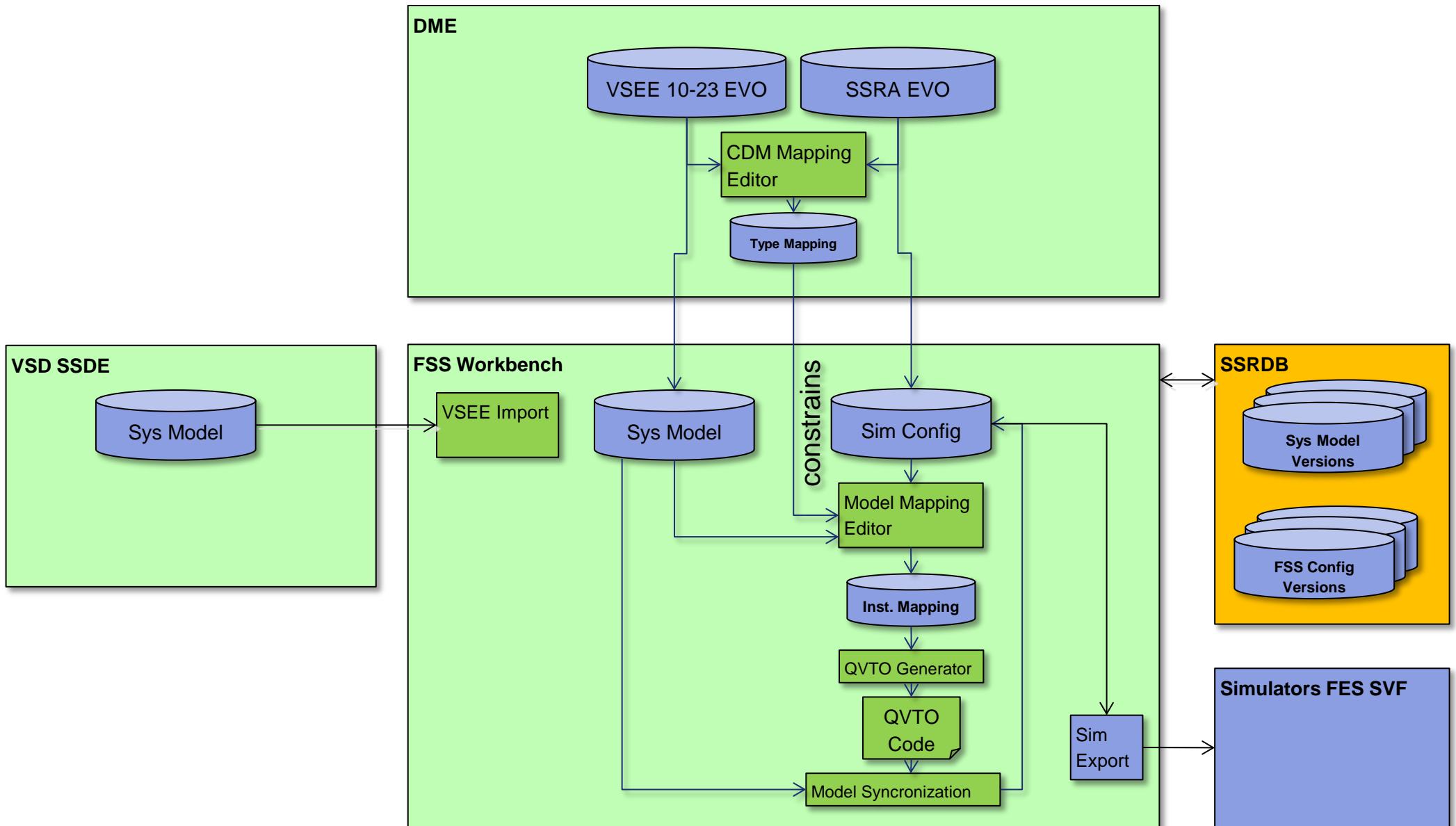
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From an FES to SVF based on Common State Machine



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Developed FSS Architecture and Tools



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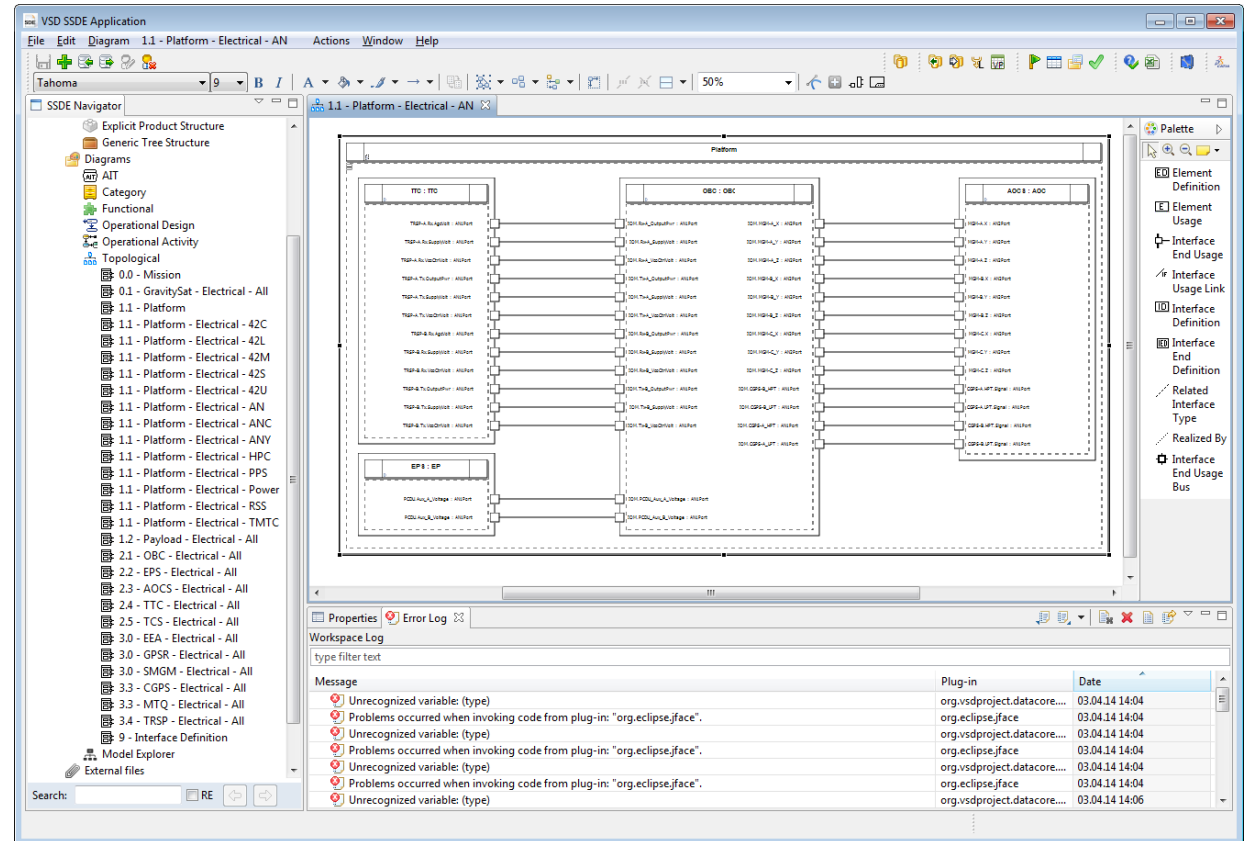
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Demonstration and Evaluation Scenarios

Overview of Demonstration and Evaluation Scenarios

All Scenarios based on GravitySat

- based on lessons learned from real missions
- Data Set contains e.g.:
 - Complete Product Structure
 - Operational Design by State Machines
 - Complete Functional Electrical Architecture
- Around 6 SubSystems + Payload
- More than 60 individual Equipment

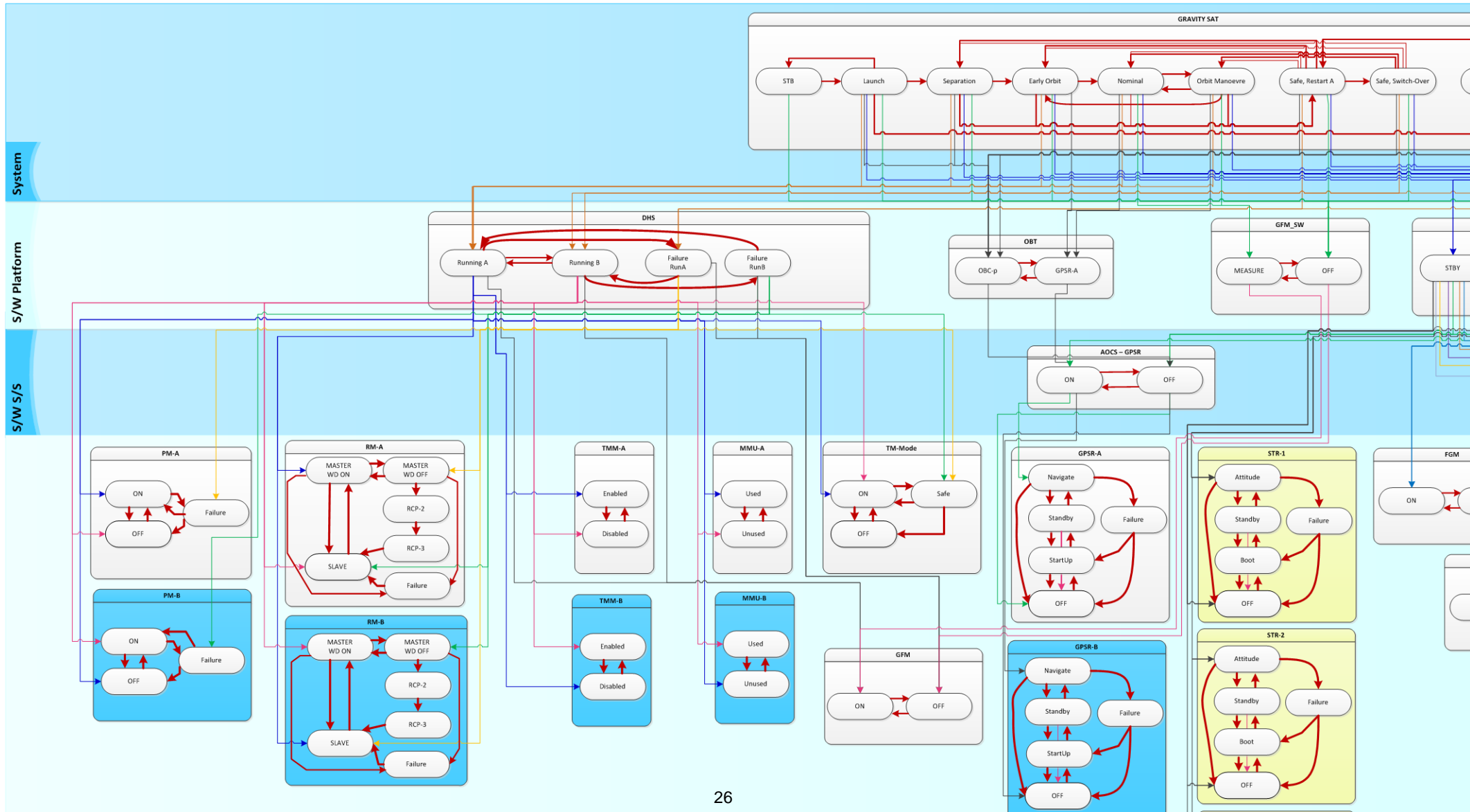


Scenarios Covered generation from System Data in various cases

- Complete FES configuration generation from System Design Data
 - Including FDIR Case with missing Mode in State Machines
 - Including FDIR Case with fixed Mode in State Machines
- Complete SVF configuration generation including Electrical Architecture

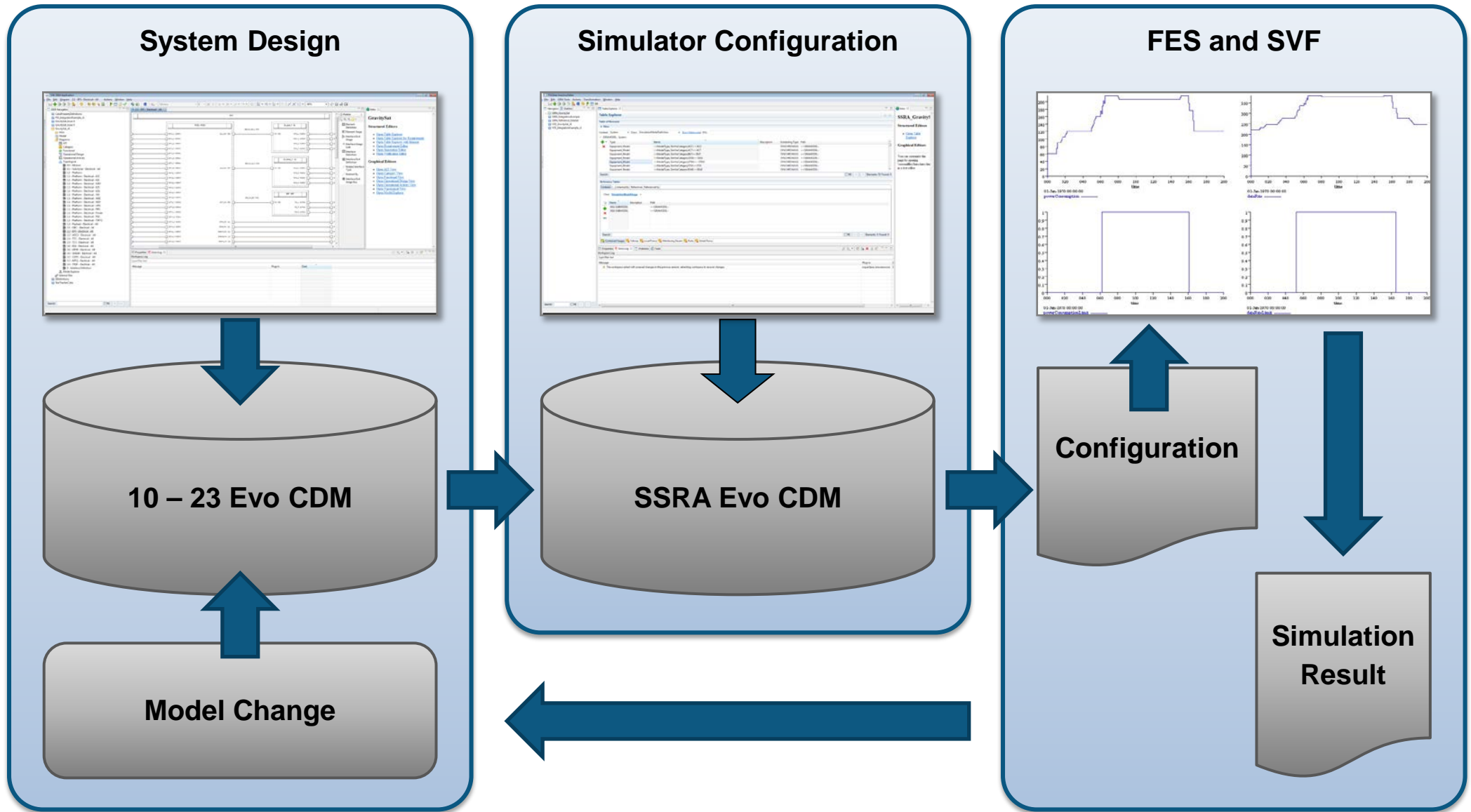
GravitySat System Model Overview and Complexity

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Functional System Simulation Process Applied to GravitySat

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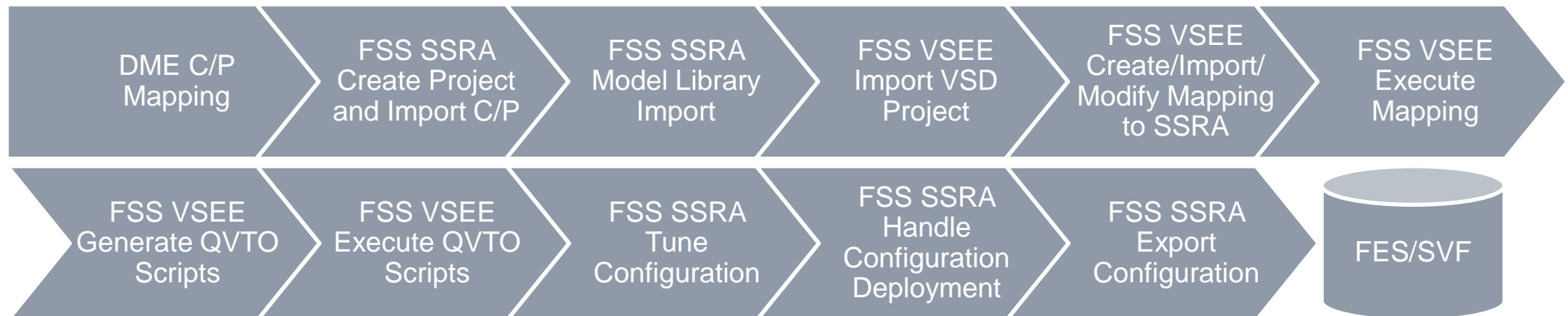


The FSS Process Mapped to Tool Interaction

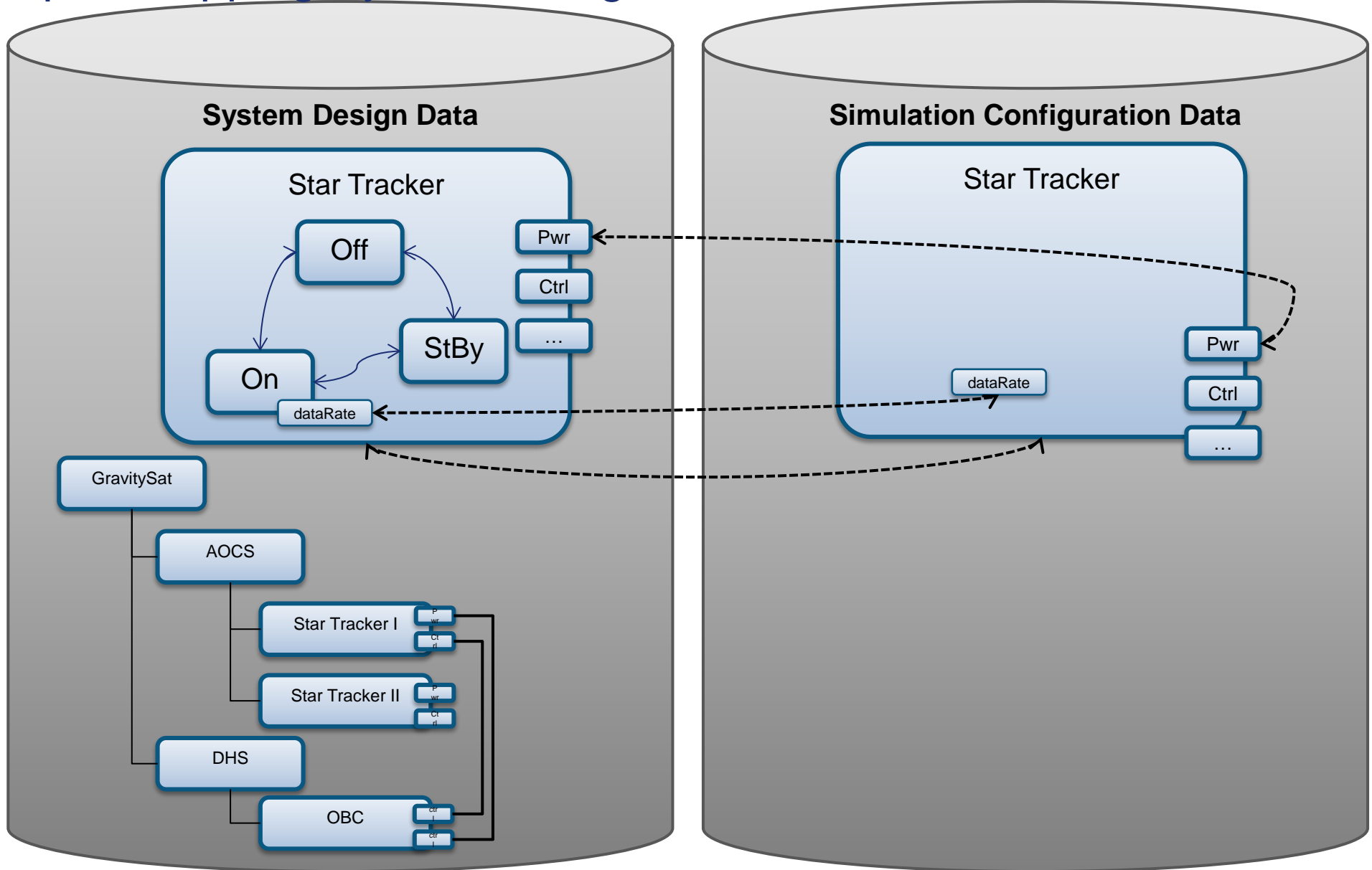
Applying the Functional System Simulation process to the developed tools means

- Precise and re-executable chain of steps to interact with tools and data
- Reuse of existing models and individual re-execution of individual steps

➔ Time Saving ... Just several minutes to regenerate simulator configuration after change.

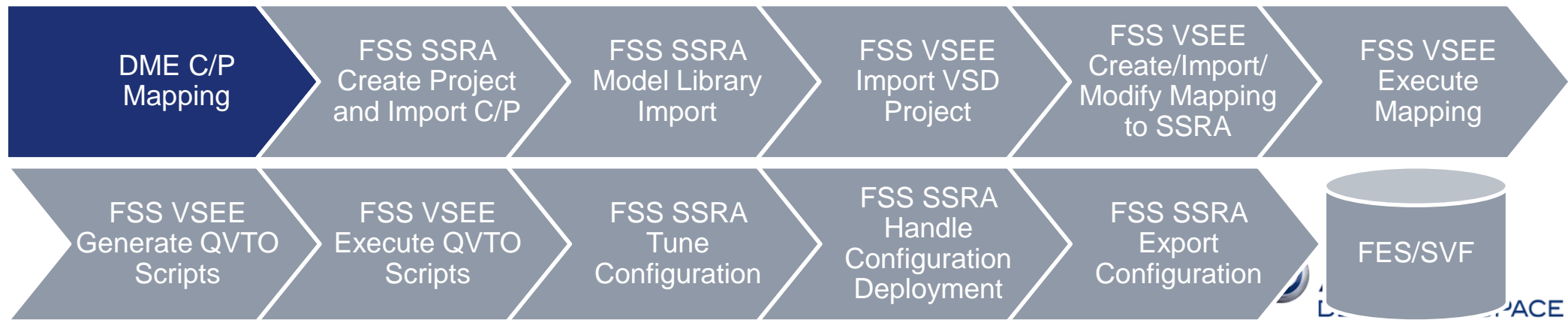
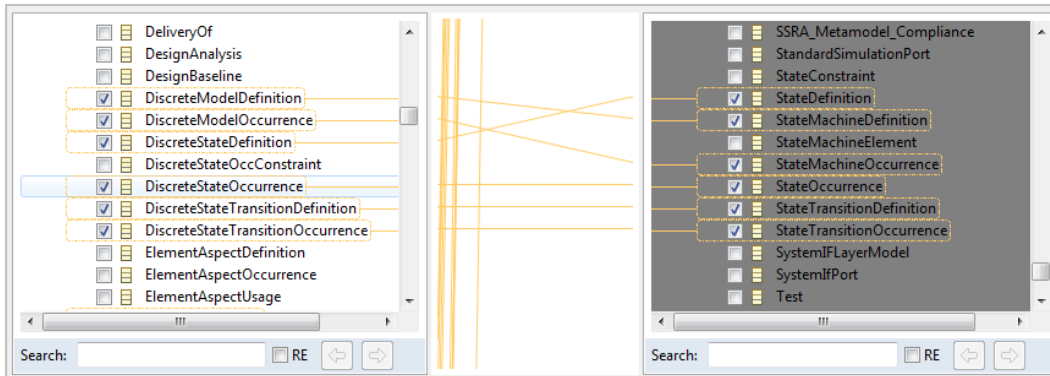
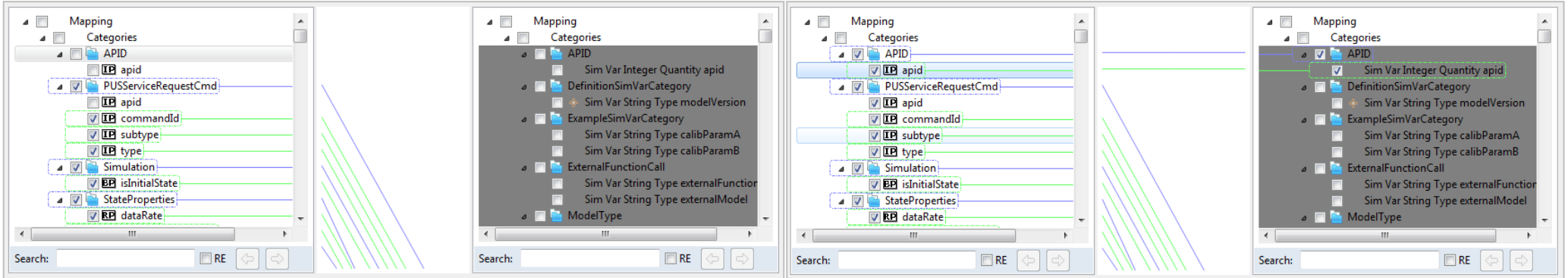


Example: Mapping System Design Information to Simulation Model



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Mapping the CDM 10-23 Evo to SSRA Evo and Categories and Prop.

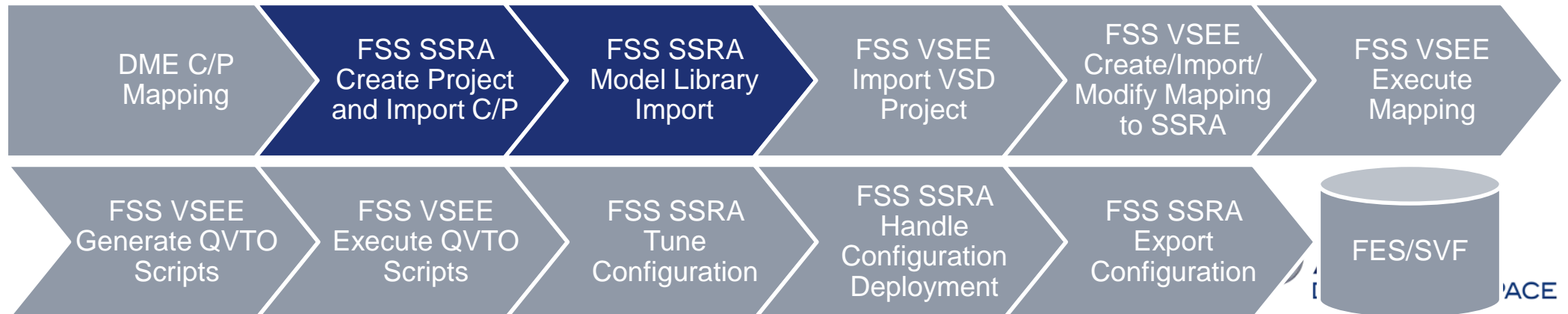


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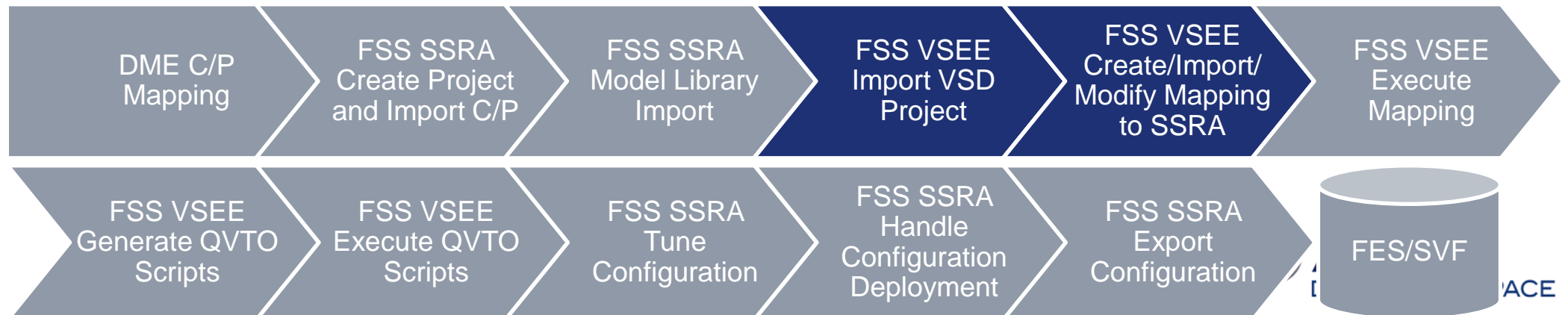
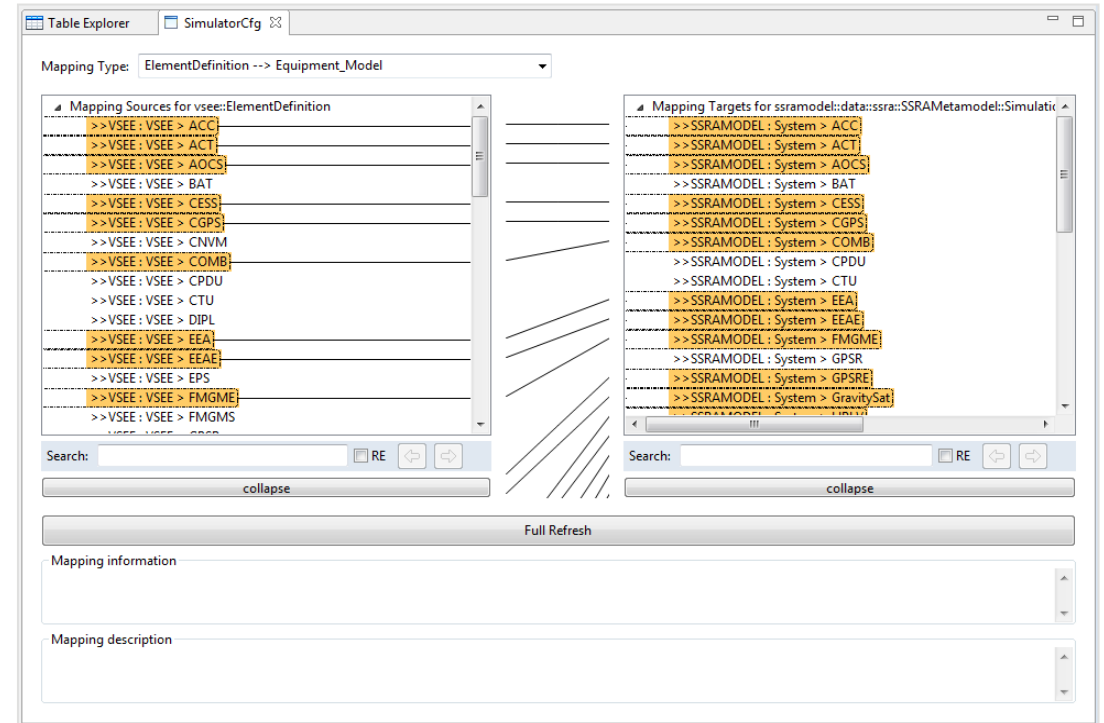
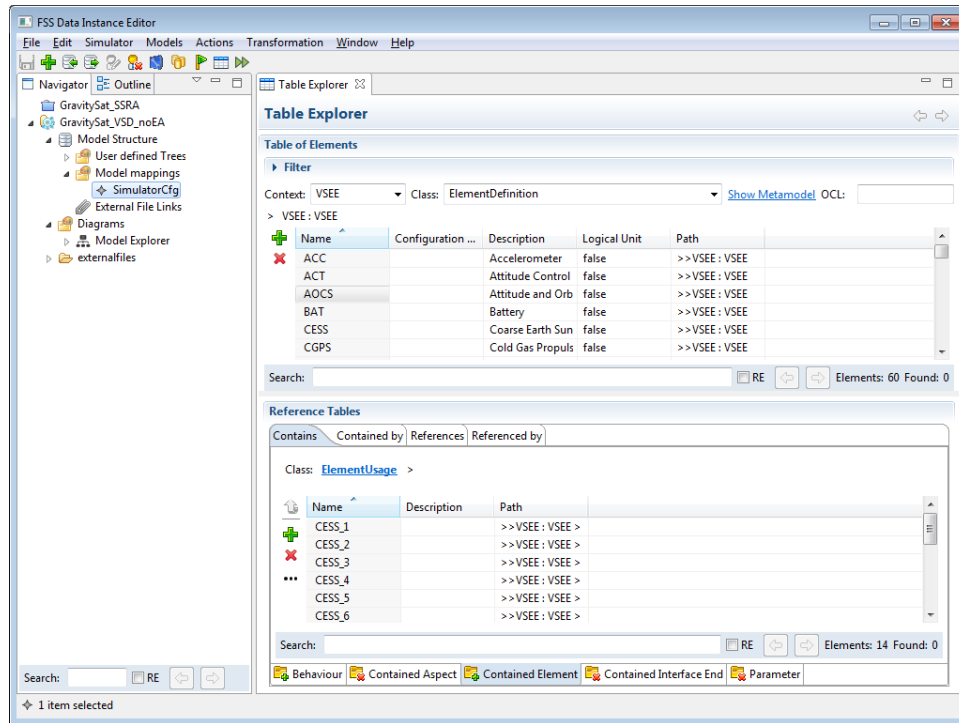
Initial Import of Simulation Models to Simulation Configuration Data

The image shows two main software windows. On the left, a 'Mapping' window displays a tree structure of categories and sub-categories, with various simulation parameters like 'apid', 'commandId', and 'type' listed. On the right, the 'FSS Data Instance Editor' window is open, showing a 'Table Explorer' with a list of elements. The 'Table Explorer' has a filter set to 'SimulationModelDefinition' and displays a table of elements with columns for Type, Name, and Path.

| Type | Name | Path |
|-----------------|--|---------------|
| Equipment_Model | <<ModelType>> ACT | >>SSRAMODEL : |
| Equipment_Model | <<ModelType>> AOCS | >>SSRAMODEL : |
| Equipment_Model | <<ModelType>> BAT | >>SSRAMODEL : |
| Equipment_Model | <<SimVarCategoryCESS, ModelType>> CESS | >>SSRAMODEL : |
| Equipment_Model | <<ModelType>> CGPS | >>SSRAMODEL : |
| Equipment_Model | <<ModelType>> COMB | >>SSRAMODEL : |
| Equipment_Model | <<ModelType>> CPDU | >>SSRAMODEL : |
| Equipment_Model | <<ModelType>> CTU | >>SSRAMODEL : |
| Equipment_Model | <<ModelType>> EEA | >>SSRAMODEL : |
| Equipment Model | <<ModelType>> EEAE | >>SSRAMODEL : |

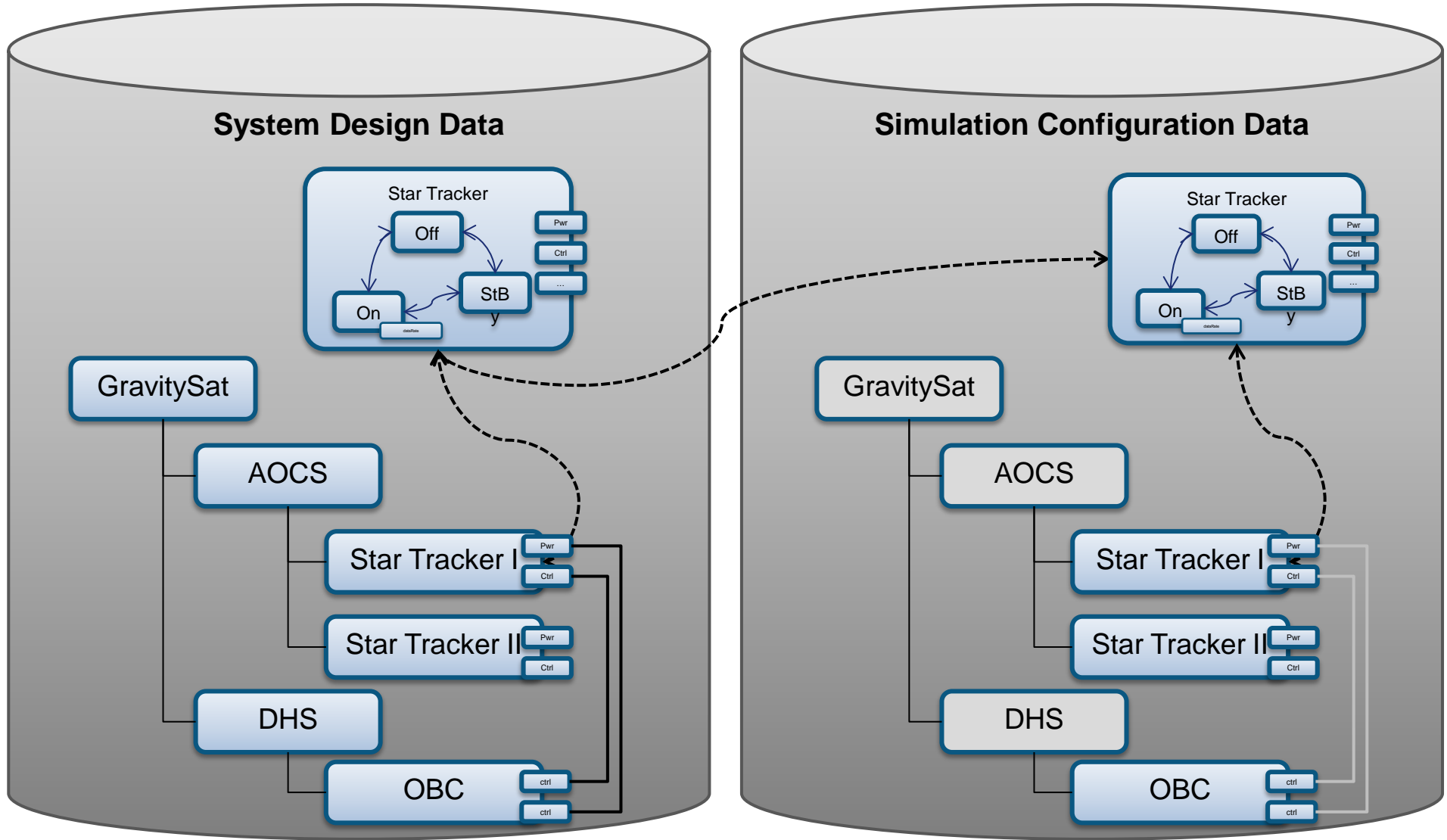


Import of VSD Authored Project and Mapping to Simulation Models



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Example: Generating Simulator Configuration



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Generate full SSRA Instance Model with Synchronization Tools

The top row shows the FSS Data Instance Editor interface. The left window displays a project tree with folders like 'External File Links', 'Diagrams', and 'Transformation'. The main editor window shows a code snippet for a transformation:

```

modelType CORE uses core('http://www.scopeset.de/model/core/v1');
modelType IN uses instanceModelMapping('http://www.scopeset.de/model/instancemodel');
modelType SOURCE uses 'http://www.scopeset.de/model/vsee/transformation';
modelType TARGET uses 'http://www.scopeset.de/SSRAModel/1.0/transformation';

transformation Source2Target(in modelIN : SOURCE, inout modelOUT : TARGET);

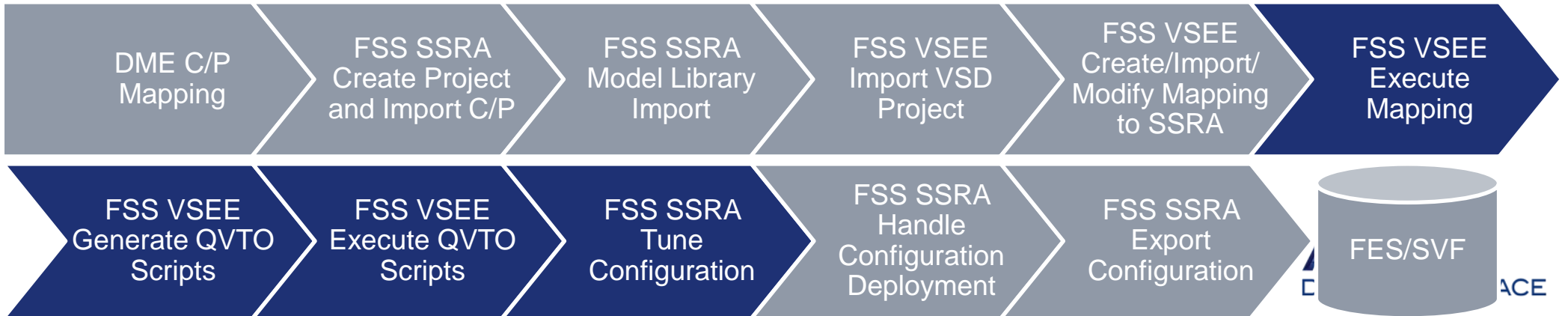
//mapping TARGET::Overall_Occurrence:ConnectionOccurrence:InterfaceOccurrence2Cor
// Variables for each possible instance (based on the type mapping)
// Also resolve the source Element
var InterfaceOccurrence:InterfaceOccurrence := self.getMatchingInterfaceOccurrence;

//Category Mapping for each source Type:
if(InterfaceOccurrence != null) then {
    then {
        map APID2APID("APID", self);
    }endif;
    if(InterfaceOccurrence.hasCategory("Simulation"))
    then {
        map Simulation2Simulation("Simulation", self);
    }endif;
    if(InterfaceOccurrence.hasCategory("StatePropertyExample"))
    then {
        map StatePropertyExample2StatePropertyExample("StatePropertyExample", self);
    }endif;
}endif;
    
```

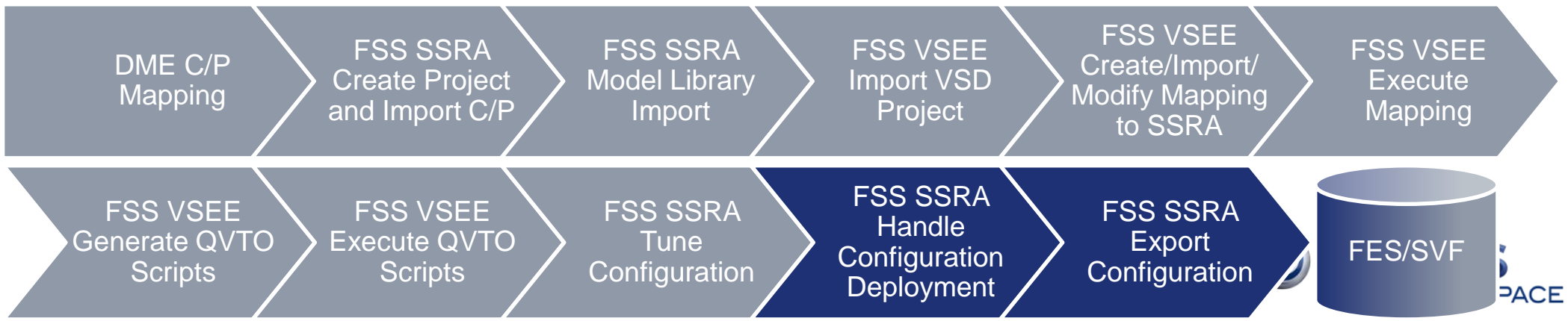
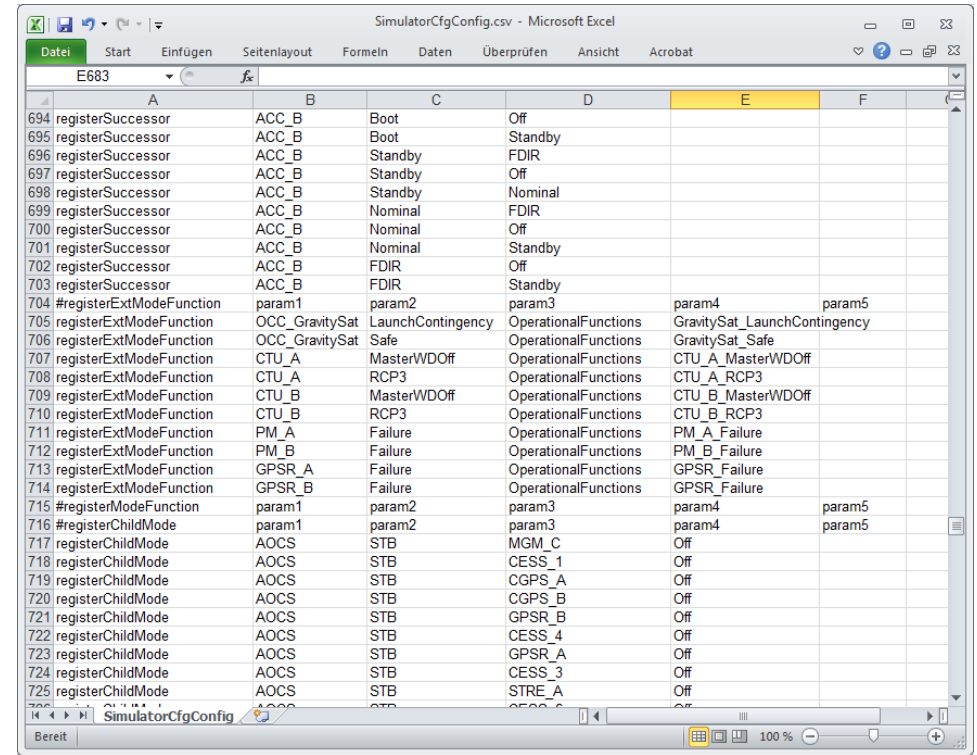
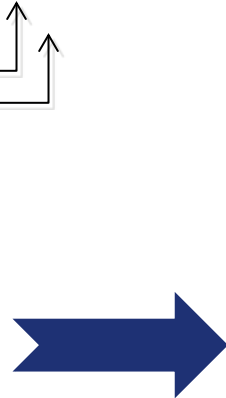
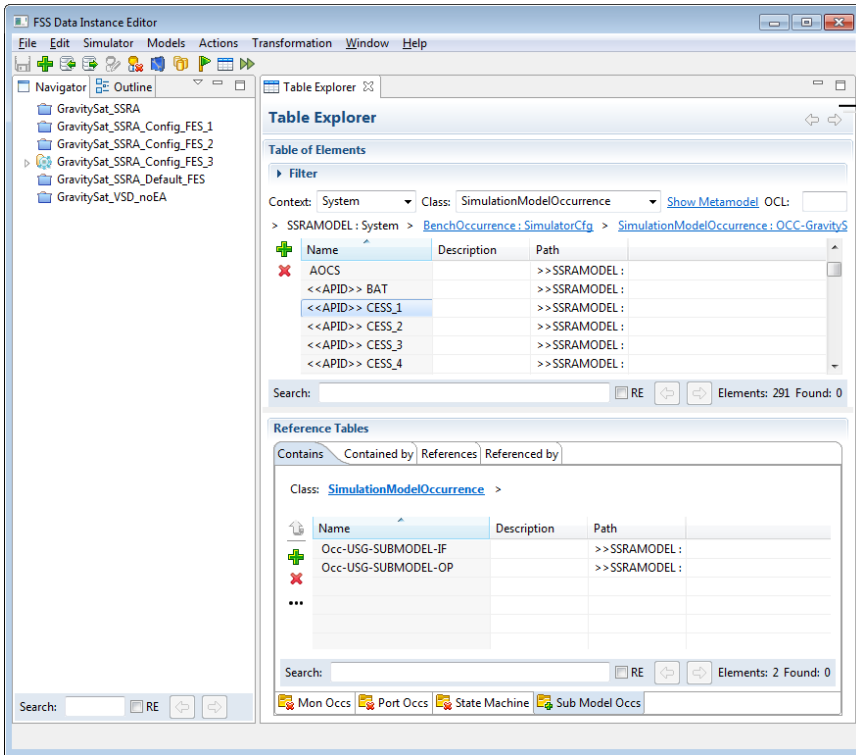
The middle window shows a table with columns for 'Mapping Type', 'Source', and 'Target', listing various model elements and their relationships.

The bottom row shows a Microsoft Excel spreadsheet with columns: Equipment, Sub Equipment, Mode, External Model, and External Function. The data includes items like PM_A, CTU_A, CTU_B, and OCC-GravitySat, with their respective modes and external models.

The right window shows the FSS Data Instance Editor's 'Table Explorer' and 'Reference Tables' sections. The 'Table Explorer' shows a hierarchy of elements under 'SimulationModelOccurrence', including 'CPDU-B', 'CTU_A', 'CTU_B', 'EEA-A', 'EEA-B', 'EEAE', 'EPS', 'FMGME-A', and 'FMGME-B'. The 'Reference Tables' section shows a table with columns 'Name', 'Description', and 'Path', listing elements like 'Occ-USG-SUBMODEL-IF' and 'Occ-USG-SUBMODEL-OP'.



Manage Configuration Data and Execute Specific Export



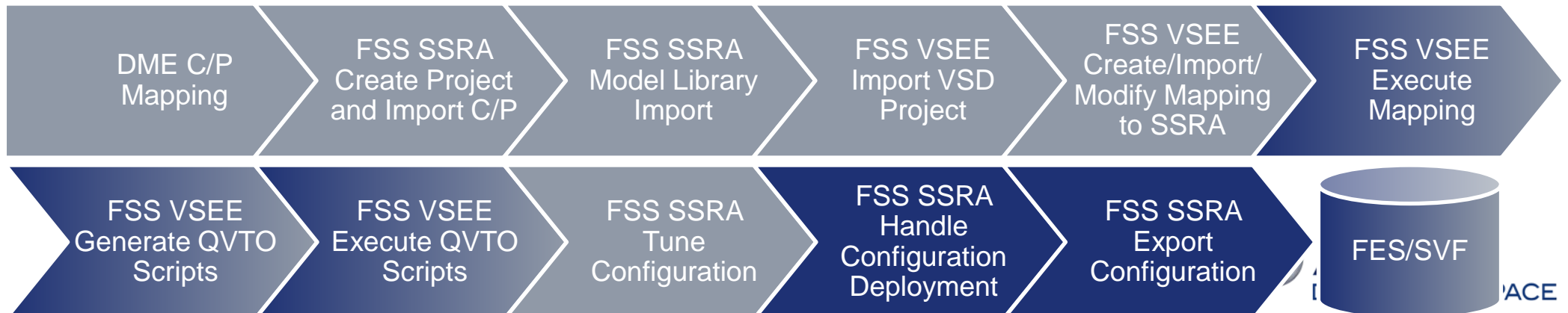
Steps to Re-Execute when Introducing Missing State

SimulatorCfgConfig.csv - Microsoft Excel

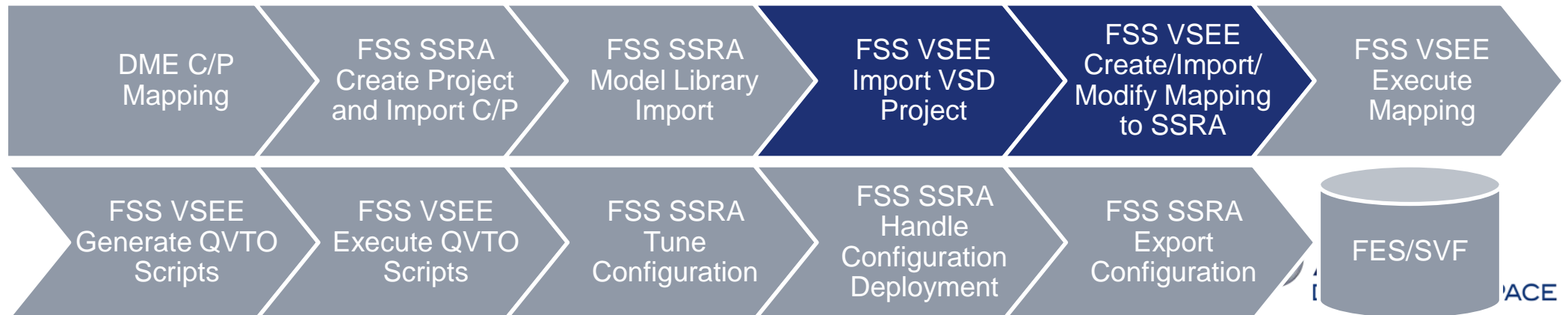
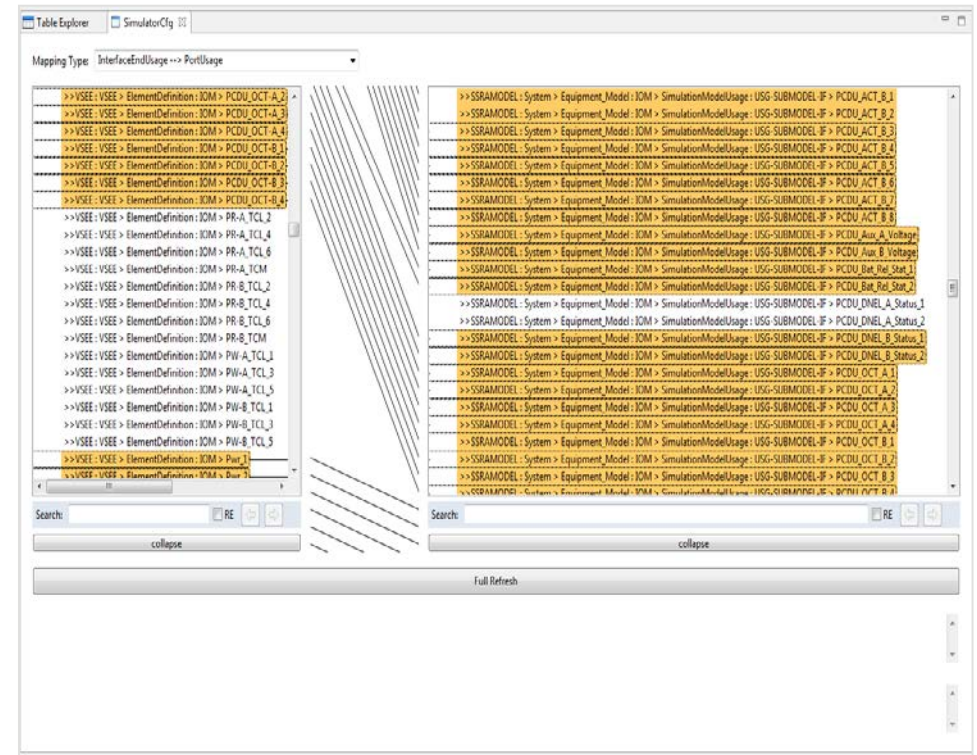
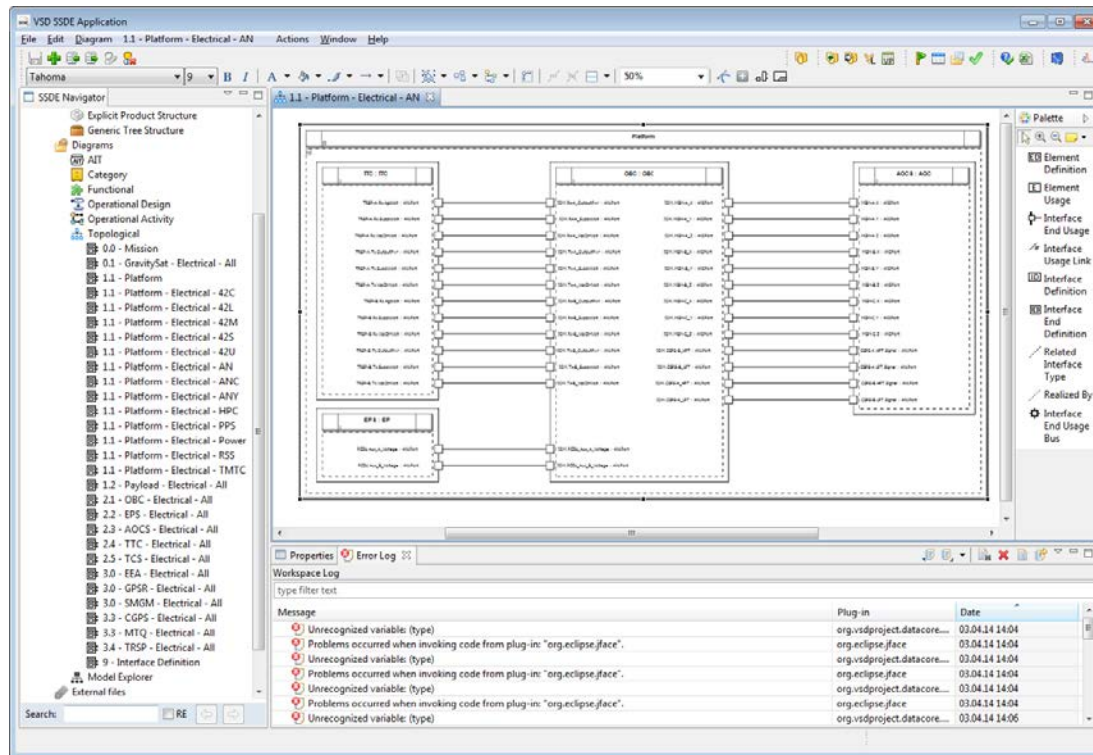
| Datei | Start | Einfüger | Seitenlay | Formeln | Daten | Überprüf | Ansicht | Acrobat |
|-------|-------------------|----------|-------------|-------------|-------|----------|---------|---------|
| B580 | | | | | CTU_B | | | |
| A | B | C | D | | | | | |
| 565 | registerSuccessor | OBC | FailRunA | Startup | | | | |
| 566 | registerSuccessor | OBC | FailRunB | RunA | | | | |
| 567 | registerSuccessor | OBC | FailRunB | Startup | | | | |
| 568 | registerSuccessor | CTU_A | MasterWDOon | MasterWDOff | | | | |
| 569 | registerSuccessor | CTU_A | MasterWDOon | SLAVE | | | | |
| 570 | registerSuccessor | CTU_A | MasterWDOon | Failure | | | | |
| 571 | registerSuccessor | CTU_A | MasterWDOff | Failure | | | | |
| 572 | registerSuccessor | CTU_A | MasterWDOff | MasterWDOon | | | | |
| 573 | registerSuccessor | CTU_A | RCP3 | SLAVE | | | | |
| 574 | registerSuccessor | CTU_A | SLAVE | MasterWDOon | | | | |
| 575 | registerSuccessor | CTU_A | Failure | SLAVE | | | | |
| 576 | registerSuccessor | CTU_A | MasterWDOff | RCP2 | | | | |
| 577 | registerSuccessor | CTU_A | RCP2 | RCP3 | | | | |
| 578 | registerSuccessor | CTU_B | MasterWDOon | MasterWDOff | | | | |
| 579 | registerSuccessor | CTU_B | MasterWDOon | SLAVE | | | | |
| 580 | registerSuccessor | CTU_B | MasterWDOon | Failure | | | | |
| 581 | registerSuccessor | CTU_B | MasterWDOff | Failure | | | | |
| 582 | registerSuccessor | CTU_B | MasterWDOff | MasterWDOon | | | | |
| 583 | registerSuccessor | CTU_B | RCP3 | SLAVE | | | | |
| 584 | registerSuccessor | CTU_B | SLAVE | MasterWDOon | | | | |
| 585 | registerSuccessor | CTU_B | Failure | SLAVE | | | | |
| 586 | registerSuccessor | CTU_B | MasterWDOff | RCP2 | | | | |
| 587 | registerSuccessor | CTU_B | RCP2 | RCP3 | | | | |
| 588 | registerSuccessor | MM_TM_A | Enabled | Disabled | | | | |
| 589 | registerSuccessor | MM_TM_A | Disabled | Enabled | | | | |
| 590 | registerSuccessor | MM_TM_B | Enabled | Disabled | | | | |
| 591 | registerSuccessor | MM_TM_B | Disabled | Enabled | | | | |
| 592 | registerSuccessor | MM_TM_C | Enabled | Disabled | | | | |
| 593 | registerSuccessor | MM_TM_C | Disabled | Enabled | | | | |

SimulatorCfgConfig.csv - TortoiseMerge

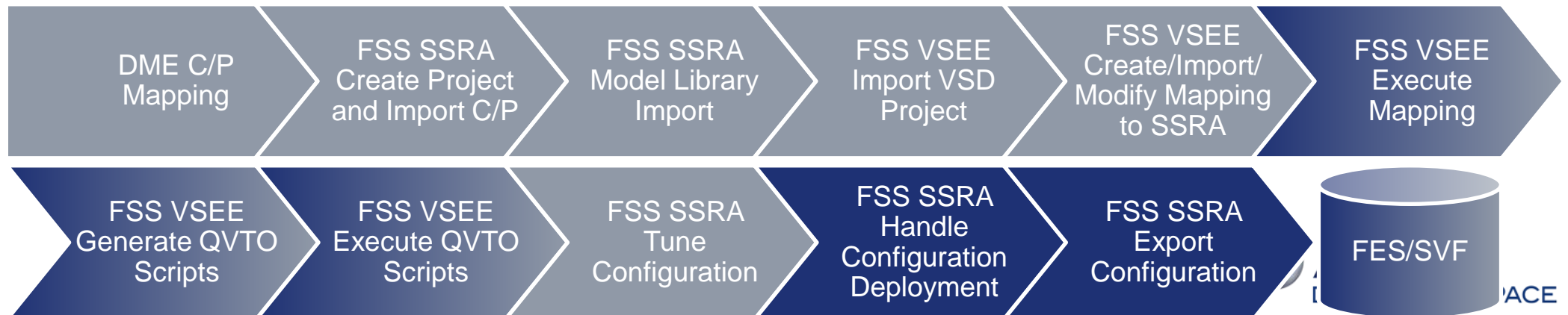
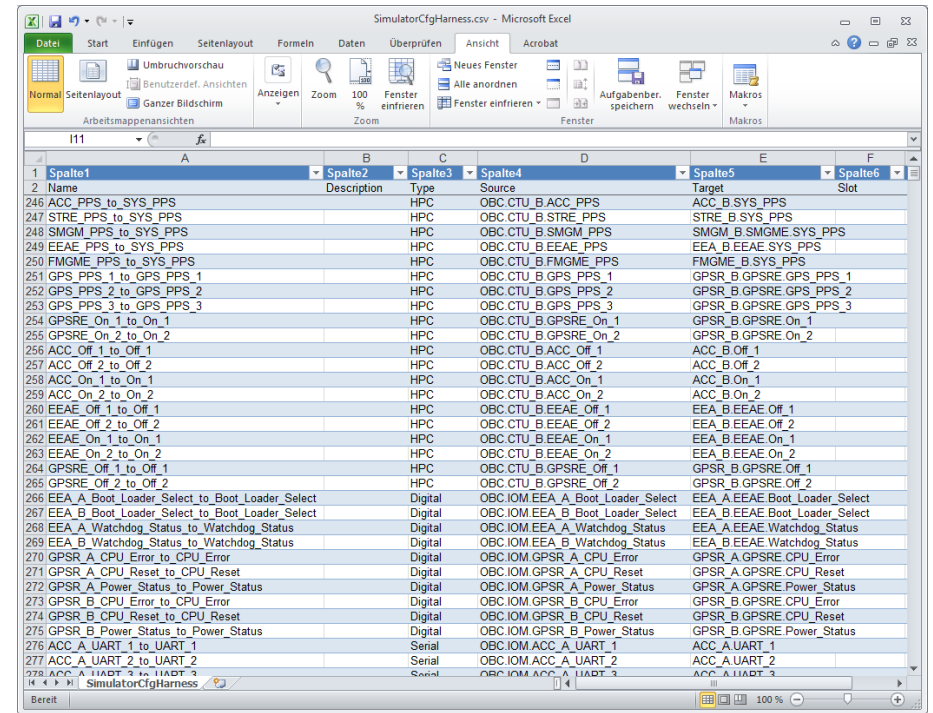
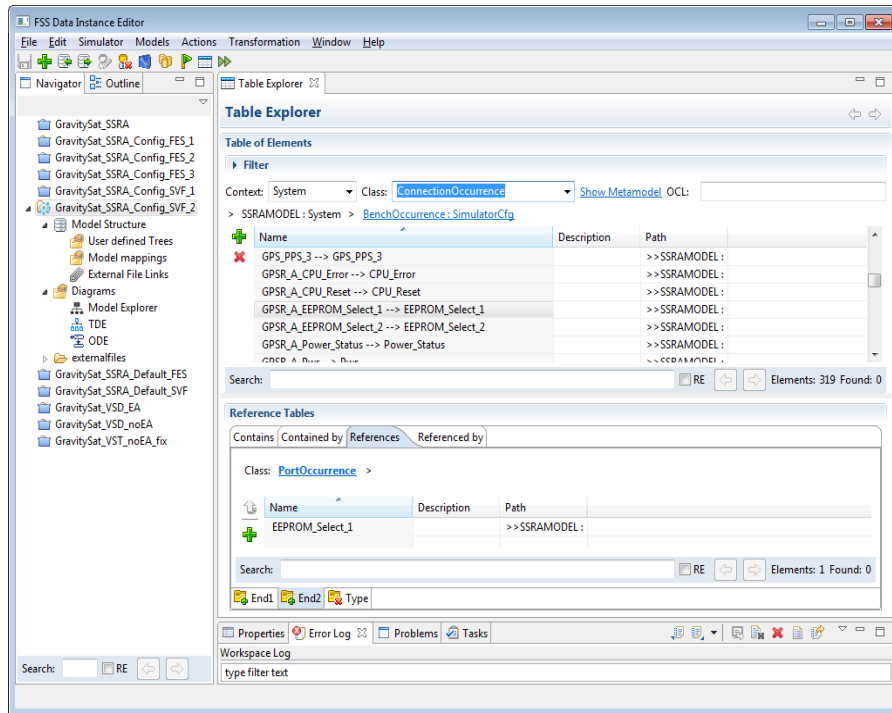
| Files | Edit | Navigate | View |
|--|---|--|---|
| Open, Save, Save as, Reload, Undo, Enable Edit, Copy, Paste, Use Blocks, Create patch file | Previous difference, Next difference, Previous conflict, Next conflict | Next inline difference, Previous inline difference, Next inline difference | Wrap long lines, Show Whitespaces, Inline diff, Inline diff word-wise |
| SimulatorCfgConfigFix.csv | 571 registerSuccessor;CTU_A;MasterWDOff;Failure;;;␣ 572 registerSuccessor;CTU_A;MasterWDOff;MasterWDOon;;;␣ 573 registerSuccessor;CTU_A;RCP3;SLAVE;;;␣ 574 registerSuccessor;CTU_A;SLAVE;MasterWDOon;;;␣ 575 registerSuccessor;CTU_A;Failure;SLAVE;;;␣ 576 registerSuccessor;CTU_A;MasterWDOff;RCP2;;;␣ 577 registerSuccessor;CTU_A;RCP2;RCP3;;;␣ 578 registerSuccessor;CTU_B;MasterWDOon;MasterWDOff;;;␣ 579 registerSuccessor;CTU_B;MasterWDOon;SLAVE;;;␣ 580 registerSuccessor;CTU_B;MasterWDOon;Failure;;;␣ 581 registerSuccessor;CTU_B;MasterWDOff;Failure;;;␣ 582 registerSuccessor;CTU_B;MasterWDOff;MasterWDOon;;;␣ 583 registerSuccessor;CTU_B;RCP3;SLAVE;;;␣ 584 registerSuccessor;CTU_B;SLAVE;MasterWDOon;;;␣ 585 registerSuccessor;CTU_B;Failure;SLAVE;;;␣ 586 registerSuccessor;CTU_B;MasterWDOff;RCP2;;;␣ 587 registerSuccessor;CTU_B;RCP2;RCP3;;;␣ 588 registerSuccessor;MM_TM_A;Enabled;Disabled;;;␣ 589 registerSuccessor;MM_TM_A;Disabled;Enabled;;;␣ 590 registerSuccessor;MM_TM_B;Enabled;Disabled;;;␣ 591 registerSuccessor;MM_TM_B;Disabled;Enabled;;;␣ 592 registerSuccessor;MM_TM_C;Enabled;Disabled;;;␣ 593 registerSuccessor;MM_TM_C;Disabled;Enabled;;;␣ | SimulatorCfgConfig.csv | 565 registerSuccessor;CTU_A;MasterWDOff;Failure;;;␣ 566 registerSuccessor;CTU_A;MasterWDOff;MasterWDOon;;;␣ 567 registerSuccessor;CTU_A;RCP3;SLAVE;;;␣ 568 registerSuccessor;CTU_A;SLAVE;MasterWDOon;;;␣ 569 registerSuccessor;CTU_A;Failure;SLAVE;;;␣ 570 registerSuccessor;CTU_A;MasterWDOff;RCP3;;;␣ 571 registerSuccessor;CTU_B;MasterWDOon;MasterWDOff;;;␣ 572 registerSuccessor;CTU_B;MasterWDOon;SLAVE;;;␣ 573 registerSuccessor;CTU_B;MasterWDOon;Failure;;;␣ 574 registerSuccessor;CTU_B;MasterWDOff;Failure;;;␣ 575 registerSuccessor;CTU_B;MasterWDOff;MasterWDOon;;;␣ 576 registerSuccessor;CTU_B;RCP3;SLAVE;;;␣ 577 registerSuccessor;CTU_B;SLAVE;MasterWDOon;;;␣ 578 registerSuccessor;CTU_B;Failure;SLAVE;;;␣ 579 registerSuccessor;CTU_B;MasterWDOff;RCP3;;;␣ 580 registerSuccessor;MM_TM_A;Enabled;Disabled;;;␣ 581 registerSuccessor;MM_TM_A;Disabled;Enabled;;;␣ 582 registerSuccessor;MM_TM_B;Enabled;Disabled;;;␣ 583 registerSuccessor;MM_TM_B;Disabled;Enabled;;;␣ 584 registerSuccessor;MM_TM_C;Enabled;Disabled;;;␣ 585 registerSuccessor;MM_TM_C;Disabled;Enabled;;;␣ |



Extending the FES Mapping to Work for SVF Configurations



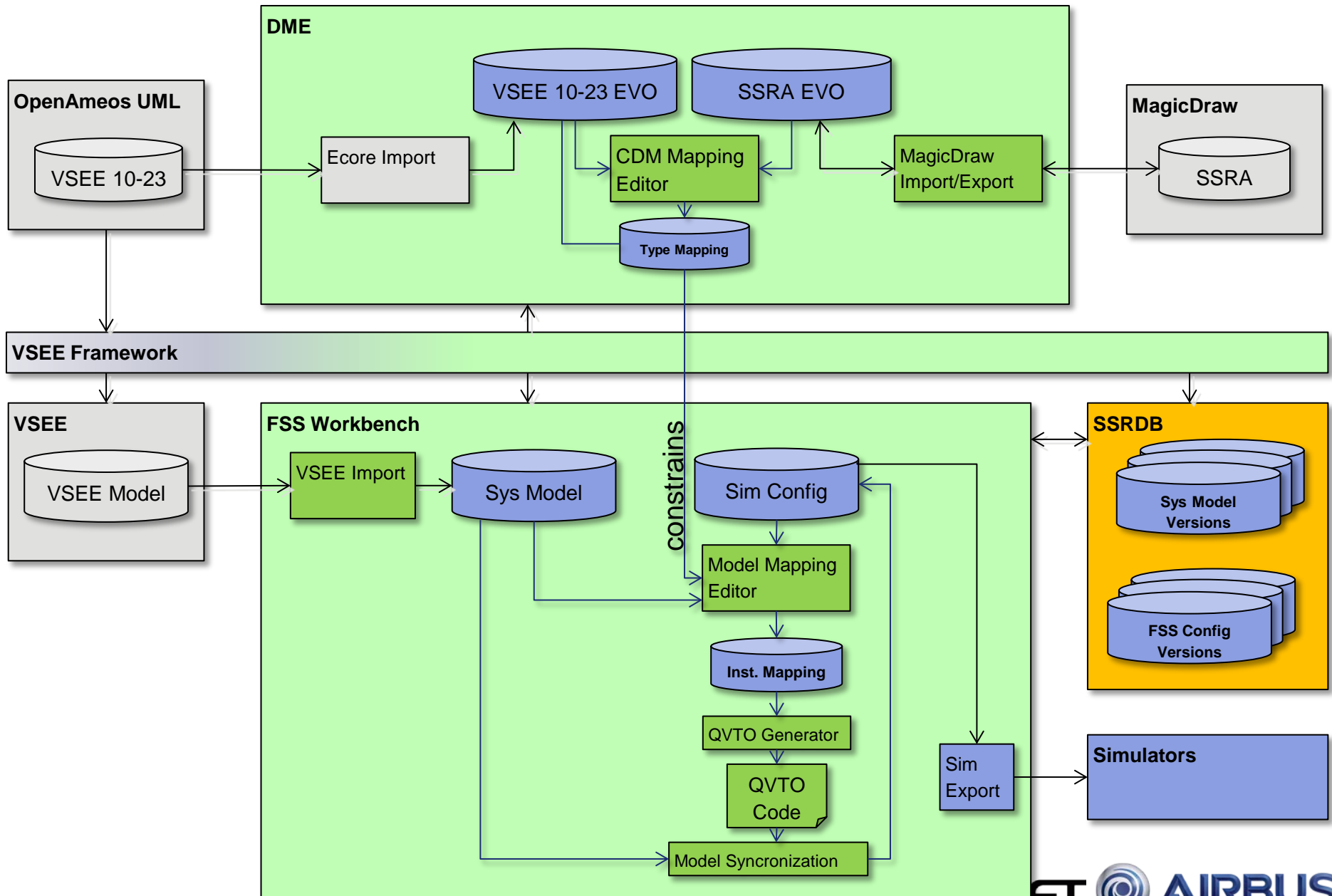
Steps to Re-Execute to Fix Issues on Electrical Architecture



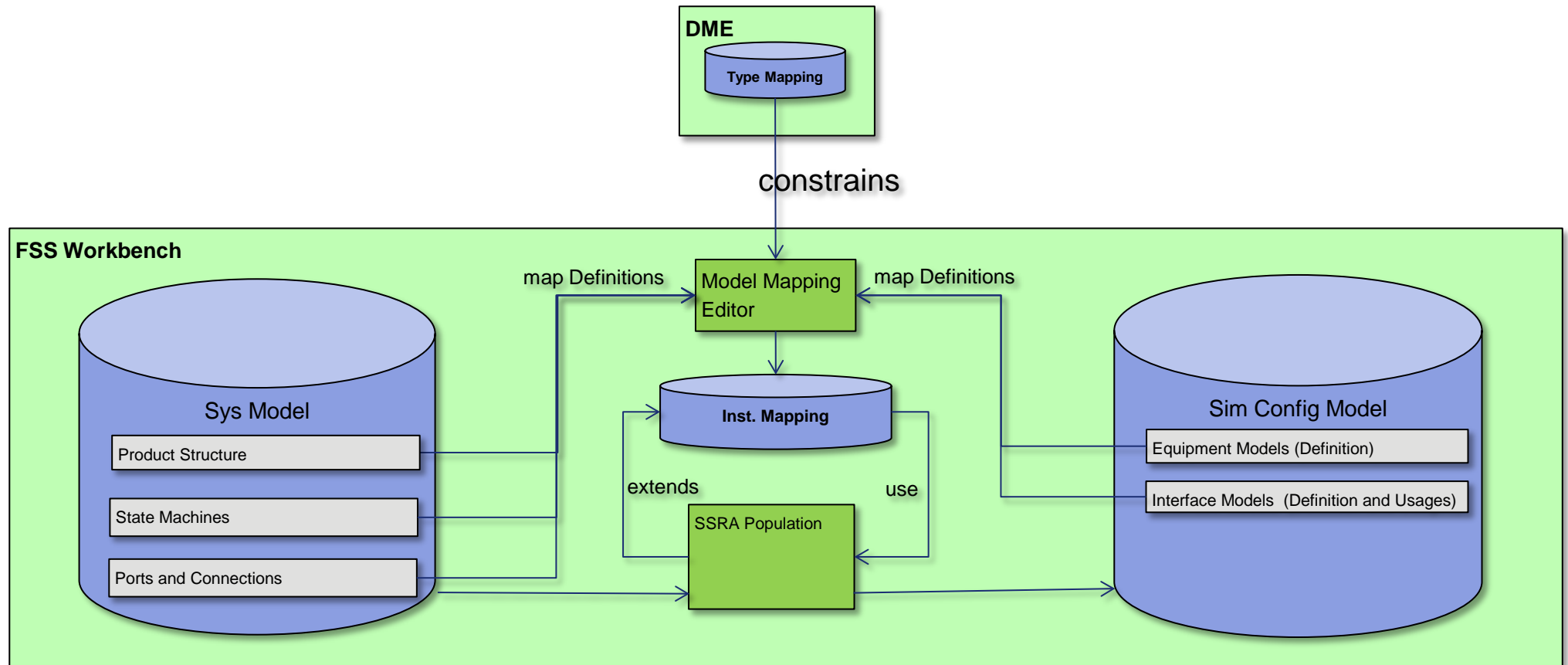
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Tools and Technical Backbone of the Study

Complete Tools Overview as in Functional System Simulation



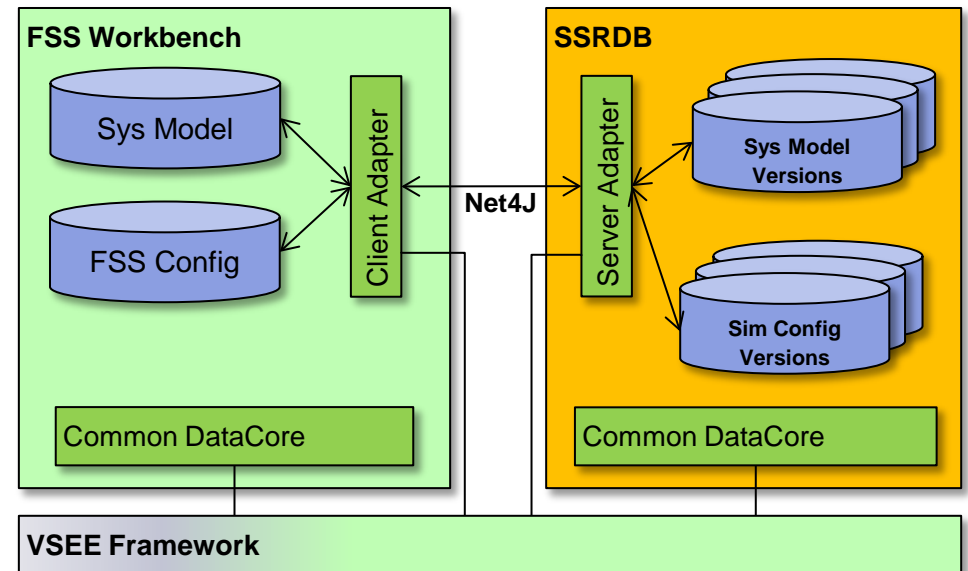
Type Mapping and Instance Mapping for Model Population



SSRDB as Configuration Control Tool for both Models

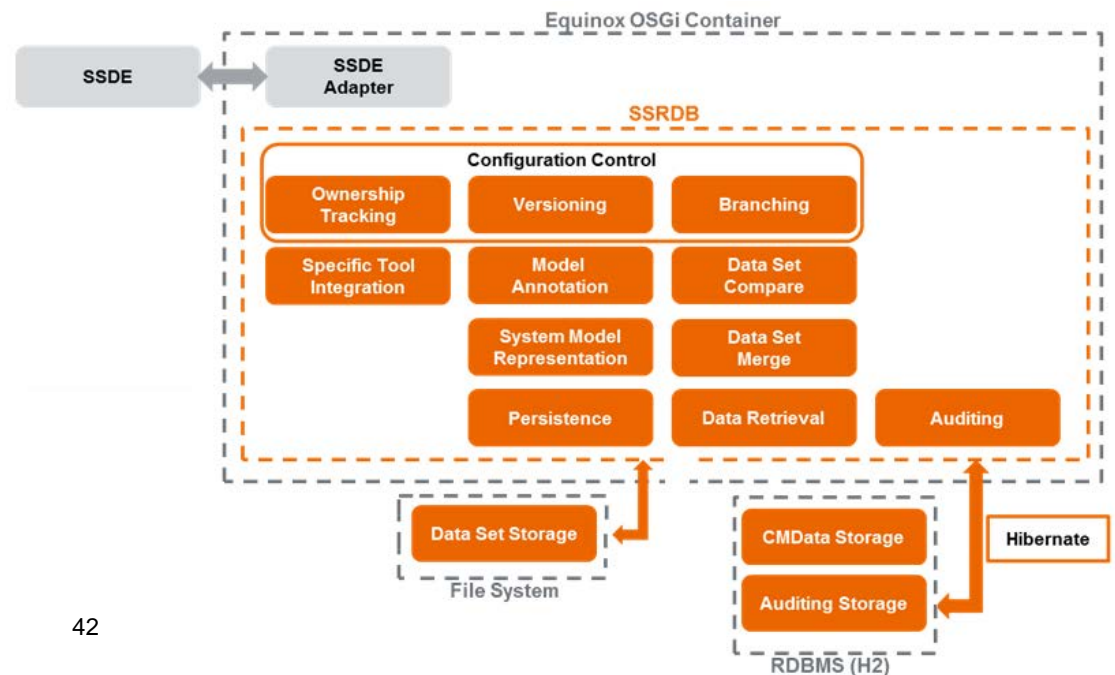
SSRDB as heritage from VSD has to evolve

- Has to handle two data models for 10-23 Evo and SSRA Evo
- Different Approaches have been discussed:
 - Solution: one SSRDB Instance maintaining both models



Tools Integration and Infrastructure

- Editors provide Adapters to SSRDB interface
- Harmonized Infrastructure using Eclipse (OSGi)
 - allows easy deployment
- Main SSRD plugins independant from data model



Summary

First step jumping the gap of system model and functional simulation

- (Semi-) automated transformation of data from system model to functional simulation model
 - Based on the different CDMs (system and simulation) the both representations can be properly related
 - The relation / mapping can be used to derive transformation scripts
 - Complementary data needed for simulation can be integrated on simulation database
 - Dependency management needed for ownership tracking and impact analysis
- Functional OBC / FSW model allow the automated configuration from system model
 - Functional OBC model can be populated from system model with i.e. the operational concept
 - More work needed to further advance functional OBC model allow to identify shortcomings in spec
- Co-management of system data and simulation data along the life-cycle
 - Decomposition of data into data sets, per managed process - equivalent functionally available for each data set
 - Modularization of data models which can be managed
 - “Growing” of simulator from FES into SVF is ensured since FES is derived from SVF
 - Update of simulation model structure needed
- Closing the loop from system model, simulation execution, run evaluation, derivation of required changes, system model update
 - The chain from system model into simulation model is closed and automated
 - The link back requires improved representation of the decision making process → annotations, tickets

End of Presentation